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THE

# PRINCIPLES OF AGRICULTURE,

BY

recht aniel
## ALBERT D. THAËR.

TRANSLATED BY

WILLIAM SHAW, ESQ.,
MEMBER OF THE COUNCIL OF THE ROYAL AGRICULTURAL SOCIETY OF ENGLA
AND HON. MEM. CER. AGRI. OF FRANCE,

AND

CUTHBERT W. JOHNSON, ESQ., F.R.S.

IN TWO VOLUMES.

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# PREFACE.

In offering to the notice of the Farmers of their country a translation of the great agricultural work of M. Von Thaer, its Editors have only to request of those skilful cultivators an extension of the same kind feeling which they have on so many former occasions experienced from them. The appearance of the work has been delayed much longer than its Editors could have anticipated, by unavoidable causes in which the reader would take but little interest.

*October* 1, 1844.

# MEMOIR OF THAER.

Of an agriculturist so celebrated on the continent of Europe, and of an author so distinguished as the author of these volumes, the English farmers will be glad to receive some information. The editors, therefore, deem it unnecessary to apologize for the introduction of this sketch, the materials of which they have chiefly obtained from his Life, published in 1839, at Leipsic, in one volume, by his son-in-law, M. Keorte.

Albrecht Daniel Thaer was born in Celle, a neat little town in Hanover, on the 14th of May, 1752. His father, Johann Friedrich Thaer, was physician to the Court, and born in Liebenwerda, in Saxony; his mother, Sophie Elisabeth, was the daughter of J. Saffe, receiver of rents and taxes of the district of Celle. Albert was the first born, and had three sisters, Christine, Albertine, and Wilhelmine, of which the first died in infancy, the second was married to Captain Schweppe, and the youngest to the well-known privy counsellor, Doctor Jacobi.

Very little would have been known of his early years of boyhood, and his academical life, were it not for some manuscripts found amongst his papers after his death, and a letter addressed to his future consort, headed, "*My Life and Confessions, for Philippine;*" in which he thus expressed himself: "My father was a cool-tempered and unaffected man. Every one who came in contact with him knew his straightforward way of acting, his scrupulous honesty; but few, very few, of his friends knew his noble and manly heart. Indifferent to praise and fame, as well as calumny, he was ever anxious to do good in silence; and it can be said of him, without fear of contradiction, that during his whole life he could never reproach himself with having been guilty of a bad or mean action.

"My mother, as much as I can remember from my early boyhood, and from what I heard of her after her death, was of a most lively temper, and possessed of a good and noble heart, but a little inclined to sensibility; her greatest pleasure was to see every one happy about her. She loved me dearly and spoilt me. I adored her. Alas, I lost her when only a little boy, and never shall I efface from my memory the day of her death and funeral. I was very sickly and weak during the first years of my infancy, and was, as much as I can remember of myself, a very whimsical boy. Sometimes I learned with enthusiasm, and often found myself in such a kind of ecstacy, that I neither could see nor hear what passed around me. In these fits of thought I forgot playthings and playfellows; I was happy only in my own musings. I always preferred the company of little girls to boys. I was not ten years old when I presented them with some poetry and little verses, the effusions of my heated imagination; some of them fell into my hands in riper years, and after reading them over, I left off poetry altogether. I loved my first private teacher very much; I even can remember him now. My second teacher was a simpleton; he could never understand me, nor enter into my feelings. My antipathy to this man grew daily greater; I could not learn of him, nor could he teach me anything. At last, when in my thirteenth year, I got rid of him, and he being encumbered with debts, I gave him my saving-box when he left. Whether I did this for pity's sake, or joy to get rid of him, I did not know. My father sent me, the same year, to school, but here I was not in my sphere; I hated the low and vulgar conduct of my school-fellows as much as the vulgar mode of correction of the masters. However, I selected some boys a little better educated for my daily companions, especially one of the name of Strauss, who unfortunately combined with his romantic ideas a great inclination to drink; we daily played truant, but nevertheless I applied myself in my private lessons with great eagerness and perseverance to the study of mathematics, history, &c., so that I contrived to ingratiate myself in the good opinion of my masters, who never missed me during the school hours, being always ready when called to my class. My best friend amongst the masters was a teacher of the French language, named Ferry, who professed secretly all the principles of freethinkers. He procured for me all the works of Voltaire, and other French freethinkers; and some time after, when I understood English, all the works of freethinkers of that nation. This was a pretty preparation for my confirmation, which was now at hand. The religious instruction I received of the Lutheran pastor Bode, preparatory to my confirmation, produced no effect upon my mind in favour of the truth of our divine religion, having studied all the works written against it with so much energy. I often insinuated to pastor Bode my doubts on religious matters, but either he did not or would not understand me; I was wavering between deism and atheism, so much so, that had it not been for the love towards my revered father, and the persuasions of Ferry, I should have avoided being present at the imposing and sacred ceremony of confirmation, which produced such an effect upon my young mind, that I prayed sincerely to God to give me faith, and had I not continued to read with Ferry and one Belzing so many blasphemous works, I should have returned to my former religious principles much sooner, as I did at a later period of my life. I continued for some time longer to ramble with Strauss and other school-fellows, to visit coffee-houses and billiard-rooms, but had a great antipathy to other debaucheries. The company of comedians of Mr. Seiler came just now to Celle, performing comedies and tragedies. This was a new life for me; I became acquainted with each individual of this company; they all were fond of me; the beautiful Madame Koch gave me lessons in dancing, and I suddenly deserted all my former companions, neglecting them to such a degree, that one Mackphail, considering my conduct as an insult to the whole school, sent me a challenge, which ended in my wounding him in the hand. My father loved me dearly, but did not much inquire into my conduct; he allowed me a great deal of money, but owing to my attachment to Ferry, whose salary was but small, I provided him with money, and having myself an extravagant taste for dress, I was often in great difficulties to pay my bills, of which my father was ignorant, till my creditors became troublesome, and my good father immediately discharged them, after giving me some kind admonition.

I was now in my sixteenth year, and for the first time it occurred to me that, although conversant with most of the modern languages, I did not understand a word of Latin, and thought the knowledge of this language indispensable to my future prospects in life. I spoke to Rector Steffens, and got permission of my father to leave school entirely, and devote my whole time to the study of Latin. In less than twelve months I was completely master of a language which is often the torment of boys from their sixth to their twentieth years, and still remain ignorant of it. Since then I have written several pamphlets in Latin, which were admired; and in Gottingen my Discourses were generally delivered in that language. Doctor Taube, physician to the king, gave me lessons in natural history, botany, and anatomy; I bade farewell to philosophy and *belles lettres*, and began in earnest, and with great perseverance, to study physic; but still I was in bad odour amongst many of the learned, and it was said, when they heard of my progress, that henceforth they should not despair of making something of the most stupid of pupils.

In my eighteenth year, my father sent me to the University of Göttingen. The first winter I did not leave the Anatomical School, and although I gave myself up to the most intense study, I willingly entered into all the gaities and amusements so much sought by German students, but avoided carefully debaucheries of any kind; they gave me the cognomen, *Half Renommist*, owing to my puerile look and feeble and weak voice. Unzer and Ebeling, two students in physic, took me under their powerful protection, and extricated me out of many scrapes.

In the second year of my residence in Göttingen, I entered my name for a course of lectures on practical physic, against the advice of all my friends, but I have never regretted so doing, as there never has been, and probably never will be, a greater man at the university than Doctor Schröder, physician to the king, who gave, at that period, his celebrated lectures on practical physic. Schröder himself was astonished at the step I had taken; but when he perceived that I fully understood him, I became one of his favourite pupils; nor had I the advantage alone of receiving private lessons *gratis*, but he took me with him in most of his professional visits, where I had all the advantages of his great practice. Thus I caught a putrid fever which was then very prevalent; Schröeder attended me day and night, and giving up all hopes of my recovery, he observed to one of his friends, not thinking that I understood what he said, "The expansion of the sinews increases." "Then," answered I, in a quiet manner, "I shall die in four days, according to such and such a rule of Hippocrates: pray, prepare my father to receive the news of my death." However, immediately after, a sudden turn in the disorder taking place, I soon recovered; not so my memory, which I lost for a time, so that I had forgotten the names of my best friends; my nerves were so completely shaken, that I had no wish to recover. After my recovery, Professor Schröeder being himself attacked with the same fever, requested of his wife that no other physician than myself should attend him; but when he became light-headed, she called in all the physicians of Göttingen, and these gentlemen not agreeing in opinion respecting the treatment of the patient, this great and learned man fell a victim to ignorance and jealousy, April 21, 1772. I cannot think of this celebrated and good man without shedding tears of regret and gratitude.

After his death I did not attend any more lectures, although I paid for them. Schröeder was succeeded by Ernst Gottfried Baldinger, born in Gross Vargula, near Erfurt, 1738; and descended in a direct line, on his mother's side, from Doctor Martin Luther. He established a dispensary for poor patients, and gave medicine *gratis*, on condition of his being attended by about thirty pupils. Here it was that I first began to display the knowledge I had gained from my friend, the late Doctor Schröeder; and Baldinger, not seeing me attend his lectures, naturally supposing I was lazy and dull of comprehension, exclaimed, with astonishment, "What will become of this boy?" Whereupon, considering myself insulted by the Doctor, I wished to retire; when he embraced me, and said, good-humouredly, "No, no! such a clever young fellow never came under my observation." From this time I became his best friend and daily visitor; I passed whole days and weeks in his valuable and extensive library, and almost in the constant society of his amiable, highly gifted, and accomplished wife; his confidence was so great, that he left the entire direction of his dispensary to me, and even entrusted me with the care of his own family when unwell. Having given up all connexion with my former friends, the students, I selected one Leisewitz, the author of "Julius de Tarent." We sympathised in each other's feelings, and became inseparable. His amiable qualities and inoffensive wit drew around us the best society; but, to our great regret, many of them belonged to a new school of freethinkers, whose principles we endeavoured, by the assistance of the pious Madame Baldinger, to eradicate from their minds; and thus it was that Providence brought me over again to the firm belief of the truth of our Divine religion.

In the mean time I paid the strictest attention to my profession, and was so completely successful, that there was no patient of any consequence in Göttingen that I was not called in to; but as I was not allowed to make up prescriptions, not having taken my degree, and in order to avoid a heavy penalty, I was accompanied in my professional visits by Doctor Tolle, a man who knew the lectures of Schröeder by heart, but did not understand them. I dictated to him what to prescribe, he took the fee, and was content. I had nothing but the honour, and plenty of good dinners. At last I took my degree as Doctor of Medicine, and resigned my patients to the care of Dr. Strohmeyer, which was the means of introducing him into practice. I left Göttingen full of honour, with tears in my eyes, at leaving behind me so many dear friends. Puffed up with pride, I arrived in Celle, but was received with coldness and pity. This was too much for me; I could not brook the insult; but said to myself, "How can I expect to be otherwise received, when I consider my former conduct, and look back on the heedless manner in which I passed my boyish years?" My consolation was, that "I should be soon as happy here as I was in Göttingen" *in the choice of my friends*. The physicians in Celle were fifteen years behind in their practice; they had heard of a new style of practice, but regarded it as a mere chimera. When I ventured to say a word or two, they did not understand me: when I appealed to some great authority, they were ignorant of it: when I spoke from my own practical experience, they looked at me, from head to foot, and said sneeringly, "Well, well; experience will come in time." But when by chance I ventured to make some proposal, they turned round, and wondered where they should find room enough in the churchyards to bury my patients. The great applause with which my Dissertations had been received in all the learned journals, even in England as well as in France, gave me courage, hoping that this circumstance would make some impression on the mind of the public; but it was generally thought I had ill employed my time, and knew little or nothing. Being obliged to frequent society, I was so disgusted with the general tone and the topics of their conversation, that I was almost in despair; at last, some young ladies treated me with more attention. I began to reconcile myself to my forlorn condition, but still I was not what I wished to be: the worst of all was, I had no friend; not a human being that understood me. I wrote daily to my friend Leisewitz; he resided in Hanover, and was just as unhappy as myself, except that he had some friends, and plenty of money. In this respect I was differently situated, and although in want of money to buy books, I was determined not to be any expense to my father. Some watches, snuff-boxes, and rings, presents I had received in Göttingen, soon found their way to the hands of Jews at half price. I was even, against my will, driven to the necessity of accepting small fees from mechanics and peasants. This cut me to the heart; but I could not help myself. The following circumstance, however, overcame me more than all: My father was a man of great knowledge and experience, but, like all old men, he remained faithful to the old method of practice. I visited many of his patients, and without telling me exactly what mode of treatment I was to pursue, he only observed, "You will act so and so;" however, I saw the patients had confidence in my father only, and not in me; they wished me to be his tool, and I therefore followed his mode of practice, and thus lost several of his patients, who could have been saved had I followed my own method. Among others, Doctor Caritens died during a momentary absence of my father, who recommended while stepping into his travelling chariot, to bleed the Doctor a second time. I did as he bid me, although convinced that emetics and opening medicine would cure the patient without fail; the Doctor died, and you may easily imagine the state of my feelings. I had just begun to publish a work on practical physic, but had no heart to finish it after this sad catastrophe. I betook myself again to philosophy. I wished daily to return to Göttingen, if I could do so with honour. I passed three years under such painful circumstances, when my friend Leisewitz invited me to go with him to Berlin, for which purpose his brother-in-law in Brunswick would advance me money to defray my expenses. Without much consideration, I accepted the invitation, and my portmanteau was soon ready. Arriving in Berlin, I found myself in my element, and began to breathe freely. Jerusalem and Lessing had given us letters of introduction to the greatest men in Berlin; but they knew us already, Leisewitz as author of "Julius Von Tarent," and myself as author of my Dissertation. We had daily the choice of the first society; covers were laid for us in the first families daily, for dinner as well as supper. Von Zetlitz sent a general invitation that covers were laid for us every day during our stay in Berlin. Most of the time we could spare was divided between physicians and philosophers, of which the latter had the greater share. Spalding, Mendelsohn, Eberhard, Engel, Nicolai, Reichard, and Madame Bamberger, daughter of Doctor Sack, Bishop of Berlin, honoured us with their most sincere friendship. The latter, a highly gifted and accomplished lady, possessed the rare art of spreading over the most abstract hypothesis and theorem the brightest and most charming light; Jerusalem, the father of the ill-fated Werther (see the "Sorrows of Werther," by Göethe), used to send her his works to correct, and she alone was able to console and comfort him, when he was informed of the death of his beloved son. This amiable lady assumes in common life the character of a plain woman, and when at court, as friend of the Queen and the Princess Amalie, she won all hearts by her truly noble manners and unconstrained courtesy: at court beloved, she was admired, nay, adored in the philosophical clubs. But do not think that here alone we spent all our time; Madame Bamberger knew how to blend study with amusement; she issued frequently cards of invitation to select parties, for suppers and balls, and her house was the point of union of all that was learned, beautiful, and amiable. Thus Berlin became my Paradise. I had the most tempting offers from the Minister of State to stay here; but the illness of my father obliged me, after a stay of three months, to return home. I visited Lessing on my journey back; stayed two days, which were the most interesting of all days I ever remember. It was now, I thought, high time to think earnestly of getting into good practice as a physician. I followed, in order to effect this, my own method; I cared not for criticism; good luck attended me; I was successful in many cases given up by others as hopeless. My father watched me now closely, but let me have free sway; he felt great pleasure at my success, and would now and then say, "Well done, my boy;" but nevertheless entreated of me not to offend a certain great personage; which, however, I frankly confessed I had already done, not caring much about it, as it was my intention not to stay in Celle. I wanted a greater sphere of action. My father's weakness and infirmity increased daily, which prevented him from visiting his patients, and determined him to give up altogether his practice, and to retire from a profession in which, during many years, he had so nobly done his duty; he informed his patients of it, telling them that they were perfectly free and at liberty to take the advice of his son, or any other physician, thereby insinuating, that in their choice they must not suffer themselves to be influenced by their feelings of friendship and regard towards him. Almost all his patients honoured me with their confidence. Now, my dear Philippine, a few words more. I am not rich; but my affairs are not in a deranged or desperate state, and were I to die to-day, and my property sold, it would fetch 5,000 dollars at least, so that I possess 2,000 dollars more than my father gave me. I have but 400 dollars salary; my practice is good, and becomes daily more lucrative; the income I derive from it now is more than sufficient to keep a good and respectable house; my prospects are flattering; but I can and must not name them at present; I will not bring them into account."

Here ends the letter addressed to his future consort; he calls it his confession, and surely the writer proves throughout that he was guided by a most sincere and open heart. He was now physician to the parish and the House of Correction, and shortly afterwards (1780), without soliciting for, or even expecting it, he was appointed Physician to the Court of Hanover.

Thaer, being now at the summit of his profession, he was called in to all consultations, far and near; his opinion always had weight. His noble demeanour, the great kindness and affability with which he treated every one, rich or poor, won all hearts. His talents were held in the highest estimation; in short, he was looked up to by all. However, Thaer (although the learned Himly called him the most talented and most successful man he ever knew in his profession) notwithstanding his great and lucrative practice, got nevertheless daily more and more tired of it. This must be attributed to the sympathy for his patients, and a kind of sensibility which he never could conquer, and which induced him, several years afterwards, to relinquish a profession of which he had been the ornament, and still, at this period, continued to be, to the greatest joy of his friends and admirers. Thaer now thought seriously of his marriage; he had opened his heart to Philippine, he loved her dearly, and was loved in return. Her parents, however, and herself being very religious and devout, could not forget his younger years; a pamphlet on religious matters, written with great freedom and wit, made a great noise amongst the orthodox clergy and laity; it was published by Lessing, under the title of "Fragments of the Unknown of Wolfenbuttel," but presumed to be written by Thaer. This circumstance was for a time a great obstacle to his happiness; but, at last, his great fame, and the general esteem he enjoyed, brought on the happy day of his union with the object of his affection. He was married on the 19th of April, 1786. His lady was the daughter of a nobleman, and President of the High Court of Appeal in Celle. His name was George William Von Willich.

Thaer, immediately after his marriage, moved from Celle to a little garden beautifully situated on the river Aller, near the town. After having bought this piece of ground, he built a small cottage upon it, furnished it handsomely, and spent there the honeymoon. He was now happy; but became daily more averse to his profession. In his hours of relaxation he amused himself by cultivating flowers, and thus became a florist. The garden became now too small for him; he enlarged it considerably, making a purchase of sixteen acres of ground, and enclosing the whole.

Thaer's garden soon became the admiration of the inhabitants of Celle; and when he began to lay out plantations and orchards, to cultivate herbage and vegetables, the whole country were astonished at his science in the art of cultivation. But Thaer was not the man to stop here, he now seriously contemplated the improvement of agriculture, and, in order to carry out his plans, he purchased a considerable tract of land. He followed his agricultural pursuits with heart and soul, at the same time not neglecting his patients. He was daily seen, when coming home from his visits, running to the plough, or occupying himself in his fields, orchard, or garden. Just about this time (1796), when he seriously contemplated the relinquishing his profession, could he do so with honour, he received from London his patent as physician to his Majesty George the Third. This honour was unexpected, not having been solicited; he could not well, under these circumstances, withdraw himself at once from his profession, but began by degrees to resign his practice, and recommend those professional men he thought most clever. Thaer having now more time on hand to pursue his favourite occupation of the improvement of agriculture, kept principally in view the establishing an experimental husbandry, and the improvement of bad and ungrateful soils to such a degree as to yield a good, or at least, a proportionate return for the money laid out: he likewise studied the best works on agriculture: Bergen's work, published 1781, on Improvement of Breeding Cattle and Stall-feeding, was very useful to him, of which work a new edition was published in Berlin, 1800, by Thaer himself, who enriched the same with his own remarks and experimental observations. He took likewise the advice of his friend Schubard von Kleefeld, so celebrated as an enthusiastic freemason, introducing the system of strict observance, or re-establishing the system of Templars. Thaer gave Schubard the name of "The ardent apostle of the culture of clover and stall-feeding:" he little thought then that he himself would soon excel him. He combined with the culture of herbage fodder the growth of carrots, cabbages, and potatoes, which latter root he most vehemently defended against its numerous adversaries and assailants. His agricultural implements were of the most ingenious kind, and mostly made in England. His work on English Husbandry was so well received in England, that the Board of Agriculture sent him unanimously their thanks. The letter was dated Whitehall, June the 6th, 1797.

"Resolved, that the thanks of this board be given to Dr. Thaer, D.M., of Celle, in Germany, and physician to his Britannic Majesty, Elector of Brunswick Lunebourg, for his late valuable communication, as well as for the intended treatise he promises to send to the board as soon as printed, comprehending a comparative view of the British and German Husbandry.

"(L.S.) Signed, JOHN SINCLAIR,
"President."

Thaer's fame was now known from one end of Europe to the other. The most celebrated agriculturists of England, France, Denmark, Germany, &c., courted his friendship; his works were studied everywhere, when, curious to relate, the farmers in his immediate neighbourhood called him the English farmer, and called his farm a toy to play with. Thaer now set out on a tour through Denmark and Germany, visiting all the great landed proprietors; he made a long stay at Essenrode with his most intimate friend Director Von Bulow. "To him," he says in a letter to a friend, "I owe my success in agricultural pursuits;" and when, in 1802, he was informed of his death, he wrote again, "In Bulow I have lost my best friend, my teacher, and benefactor. I shall ever remember this truly noble man, and shall ever be grateful to him."

Thaer received a great many visitors of distinction anxious to see his establishment and visit his school for the study of agriculture, which he had lately formed. Amongst the first was Baron von Hardenburg, afterwards so well known as first minister and great chancellor of the King of Russia, with the title of Prince Hardenburg; he was accompanied by the talented Benjamin Constant, who had married the Countess Hardenburg. These frequent visits, and the immense number of letters he received from all parts of Europe, and many of which he was obliged to answer, took up much of his time; so that he was, although reluctantly, obliged to request his numerous correspondents, through most of the continental newspapers, to spare him as much as possible, and not to write to him on trivial matters. The year 1803 was fatal to him—the French occupied Hanover; he immediately sent his wife and two children to Prussia, where they were most heartily received by the Countess Von Hzenplitz in the Mark, and stayed there till the French army evacuated Hanover. The French Generals Mortier, and afterwards Bernadotte, treated Thaer with great kindness and respect. His property was protected; he continued his pursuits quite unmolested as well in his school as in the field; but his heart ached; he saw his country wasted; he feared the French would keep possession of Hanover for a length of time; or should they be obliged to evacuate it, a war, in which Prussia and Russia would take part, must ensue, and the whole country would be ruined. He had received several letters from Hardenburg, inviting him to settle in Prussia, and although the offers were tempting, he declined accepting them; till at last he received a pressing letter from the king himself, inviting him to come and reside in Prussia. The following advantages were granted:—

1. Thaer's nomination as member of the Academy of Sciences.

2. A grant of 400 acres of land in the district of Wollup; but

3. Should this land not suit for agricultural experiments, or the situation of Wollup not be eligible for the establishment of an agricultural academy, Thaer was at liberty to sell the land and buy a freehold, granting him all the privileges attached to a landed estate belonging to a nobleman.

4. Protection granted to his academy, and such privileges as are requisite for obtaining the object for which it is established.

5. Entire liberty of the press in regard to the Agricultural Journal, of which Thaer was the editor.

6. Permission to practise his profession as physician.

7. His nomination as privy counsellor.

Thaer set out for Berlin in June, 1804, accepting the offers of the king; took possession of the 400 acres of land, sold it immediately, and bought a landed estate called Möglin, with all the privileges of a nobleman attached to it, and added to it a large farm called Königshof, not far off. This property is situated in the Mittel Mark, about five German miles distant from Berlin. He took possession of Möglin on the 30th of June, 1804, and returned once more to his native town in order to arrange his affairs and take leave of his numerous friends. He did not lose time, but immediately sold by public auction all his property; even his valuable library and medical apparatus were assigned to the hammer. He closed his school at Michaelmas, took an affectionate leave of his pupils and friends, and left Celle on the first of October, accompanied by his family, his friend Einhoff, and his gardener and family, in all 23 persons. On his arrival in Prussia, Thaer was not idle; he immediately took such measures as would best insure the object of his undertaking. In the purchase of Möglin, he had not consulted his own interest, the soil being rather poor; but his establishment being experimental, his sole aim was to improve the soil, and to bring it to such a state of cultivation as to insure a commensurate return in proportion to the capital and labour. The first years of his residence in Möglin proved unfortunate to him; the rot destroyed most of his flock of sheep; then came the preparation for the war of 1806, so unfortunate for Prussia ; the occupation of the whole kingdom by the French for some years; the great want of money, and impoverishment of the middle and labouring classes, and the devastation of the greatest part of the country. Thaer could not foresee the great calamities which assailed him almost on his entrance in Prussia; but notwithstanding all those untoward circumstances, he stood firm, devoting most of his time to study, hoping that soon he might be enabled to establish his academy. He considered it as his duty towards the king and the whole country to keep his promise as soon as circumstances of a more favourable nature would enable him so to do. The building was, indeed, finished by June, 1806, and the opening of the academy was fixed to take place on the 16th of October; but then came the battle of Jena and its consequences. Thaer still despaired not, and to his great joy he received twenty pupils during the following year; this number increased yearly, and at length he had the great satisfaction and unspeakable pleasure of seeing his great work finished. It is needless to say, that after the peace of Tilsit, when Prussia recovered from the deep wounds that the war had inflicted, Thaer was not idle in the cultivation of his estate, which he brought at last to the highest state of perfection; but above all, he distinguished himself more than any one before by improving the quality of sheep's wool. He stood now on the pinnacle of his glory; almost all the sovereigns of Europe complimented him on his great success. Those of Prussia, Russia, Saxony, Hanover, Bavaria, and Wirtemberg sent him their orders of knighthood; noblemen from all parts of the world came to visit him, especially from England. They always met with a truly cordial and hospitable reception; he made no distinction between high or low, rich or poor, provided they conversed with him on agriculture or breeding of cattle, and had some knowledge of it. Thaer enjoyed good health till 1824, when he suffered much from rheumatism and a troublesome cough. He visited, during the summer, the watering-place Obersalzbrunn; but deriving little benefit from drinking the waters, and not being accustomed to an idle life, he soon returned home; the chief reason, however, was, that the etiquette of the place would not allow him the smoking his pipe, of which he was very fond. He made a last purchase of the united freeholds of Ludersdorf and Biesdorf, which he destined for his younger son, Albrecht, who was entirely devoted to agricultural pursuits. His strength now began to fail daily, and he kept his bed during the winters of 1826 and 1827, and had his pupils called in for instruction. However, as the disease under which he laboured increased, no hope for his recovery could be any longer entertained. His mental faculties remained in full force, but his eye-sight failed entirely, and one of his children was always with him and reading to him. His sufferings were great, but he bore them with great fortitude and resignation. The most celebrated medical men in the kingdom visited him, and paid the greatest attention to his complaint. Doctor Dieffenbach was in constant attendance; but he sunk gradually, till at last, on the 26th October, 1828, death put an end to his sufferings, deeply lamented by his family. He left a wife and six children, and a circle of numerous friends. He was, according to his desire, buried in his garden, close to the church, without any display. No monument marks the spot where the ashes of this great man lie; and if you pass by and inquire after the grave of Thaer, you are shown a little hillock covered with flowers.

Thaer was the author of a great many useful works. It is to be regretted that most of his manuscripts and journals were lost on his moving from Celle to Möglin; they were packed in two boxes and sent up the Elbe; the winter setting in very early, and being very severe, the ship was frozen in, and on arriving at the place of destination in the following spring, these two boxes could never be found, although Thaer, assisted by the government, did all he could to recover them.

## CHRONOLOGICAL LIST

OF

## THAER'S AGRICULTURAL WRITINGS.

1798. An Introduction to a Knowledge of English Agriculture; containing the latest Practical and Theoretical Intelligence, with a view to the improvement of German Agriculture; 3 vols., published in parts, between 1798 and 1804; third edition, 1806.

1799. Annals of Lower Saxon Agriculture, 1799 to 1804; four parts to each year (whether published quarterly not stated); idea taken from Young's work; substance republished under the following title: "Miscellaneous Writings on Agriculture;" 3 parts, Hanover, 1805-6.

1800. Bergen's Introduction to Breeding of Cattle, or rather to *Fodder Culture*, with remarks, corrections, and additions, by A. T. Thaer; Berlin, 1800.

1803. A Description of the most useful Agricultural Implements, with drawings to scale; 8 parts, Hanover, by Hahn, 1803, 4to.

Publication interrupted by the war.

1804. Benjamin Bell's Agricultural Essays; translated, with Explanatory Notes, by A. T. Thaer, 1 part, Berlin, 1804; together with Rhapsodical Observations on the above Essays, 1804.

Publication interrupted by the war.

1805. Annals of Agriculture (6 years, 1805 to 1810); in 12 vols.

1807-8. Thaer edited a work by Meyer on Irrigation, and Einhof's Chemistry of Agriculture.

1810. *Principles of Rational Agriculture;* 1*st vol. in* 4*to., and* 3 *more vols. between* 1810 *and* 1812.

The three first volumes have the signature of Thaer on the title-page, as a security against pirated editions. But before the second part appeared, the first was already issued by some German pirates.

1811. Annals of the Theoretical and Practical Progress of Agriculture, 1811 and 1812; 4 vols. 8vo., contained under the title of "Möglinischen's Annals of Agriculture," from 1817 to 1823, when the editorship, on account of the weakness of Thaer's sight, was transferred to Professor Körte, his son-in-law.

1811. Text-book for the Breeding of Fine-woolled Sheep. Published by desire of the Minister of the Interior. Berlin, 1811. (Superseded by another work in 1825; see that year.)

1812. Essay on Large and Small Farms, and Valuation of the land. Berlin.

1813. An Attempt to Ascertain the Net Produce of Farms.

1815. Introduction to a General System of Agricultural Knowledge. Berlin, 1815.

This work is said to have been that on which Thaer most prided himself. He often called it "the quintessence of the two first parts of the 'Rational Agriculture.'"

1815. History of my Farming. Berlin. This book contains an account of Thaer's experiments at the model-farm at Möglin.

1815. Sketch of a Circular to obtain more Correct Information as to the Net-Produce, to serve as a basis for correct Taxation of the Land.

1825. On Wool and Sheep-breeding; by Pérault de Jotemps, Fabry, and Girod. Translated from the French, and rendered conformable to the Present State of Knowledge of the Subject in Germany. Berlin, 1825.

THE

# PRINCIPLES OF AGRICULTURE.

## SECTION I.

## THE FUNDAMENTAL PRINCIPLES.

### A SKETCH OF SYSTEMATIC AGRICULTURE.*

AGRICULTURE is the art of deriving from the earth the most valuable organic productions. He who exercises this art, seeks to obtain profit by causing to grow, and by using, its animal and vegetable productions. The more considerable the gain derived, therefore, the better is the object accomplished. The most perfect agriculture is, evidently, that which produces, by the application of labour, the largest and the most permanent profit in comparison with the means employed. Systematic agriculture ought, then, to teach us all the circumstances by means of which we may derive the most considerable profit by the practice of the art. Now, there are three methods of teaching or of learning the practice of agriculture.

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* In the translation of this admirable work of M. Von Thaer, the editors have adhered as closely to the text of the lamented author as possible—they have only omitted those portions which seemed but little interesting to the English farmer.

1. As an occupation, by the manual exercise of it. 2. As an art. 3. As a science.

The skilful practice of agriculture, as an occupation, is limited to the imitation of certain operations, and the observation of events and circumstances. It is nothing more, when thus pursued, than a simple mechanical art: for the practical farmer can only imitate and repeat the ordinary operations of agriculture, occasionally modified by times and circumstances; and often, perhaps, without considering or even knowing the motives by which he is governed.

The art of agriculture is the realization of some ideal object. He who practises it has received from others, without considering the reasons on which it is founded, the idea or rule by which he proceeds. The skilful practice of an art consists, therefore, in the adoption of new ideas, in the study of new rules, and in judging the fitness of their being carried into practice.

The science of agriculture does not lay down any positive rules, but it develops the motives by which the best possible method of proceeding may be discovered and successfully pursued. In fact, the art executes some law given and received, but it is from science that law emanates.

Science alone can be of universal utility, embrace the whole extent of a subject, and enable us to devise the best execution of it under every possible circumstance. Every positive direction is applicable only to some determinate case, and each case requires a special rule which science alone can supply. That system of agriculture can only be called the most perfect which is the most reasonable, for these are synonymous terms.

The manual exercise and study of the art can never be useless to the agriculturist who wishes to elevate it to the rank of a science, and to the mental consideration of which it is deserving. It will be advantageous to him to have experienced the labour and the energy which are necessary, in order that he may judge of the mechanical execution of the various portions of it.

A purely practical agriculturist is compelled to follow the rule which has been laid down for him, although it may not be wholly applicable to the peculiar case which presents itself. He cannot depart from it without adopting some other rule, which may, perhaps, deviate entirely from the first.

This is the reason that so many agriculturists, who have practised with success in other countries, and under other circumstances, on being removed elsewhere, have committed very deplorable blunders.

Thus, the man who has not studied the science of agriculture can make little use of books, or even the best of them. He knows not how to arrange the new ideas which they unfold, and he cannot follow them in their fullest extent. All that he dares do is to read those books which have the closest relation with the circumstances in which he is placed.

### THE BASES OF THE SCIENCE OF AGRICULTURE.

The science of agriculture rests on experience; and nothing else should be required or expected from it but that which appertains to a practical science. The first principles arise from the perceptions of the senses; but if experience wholly and entirely flowed from these perceptions, the development would not be less the offspring of science and the work of the understanding.

From the frequent union and the succession of objects, we conclude that a certain fact is the consequence or result of another; and it is the source of a vast number of errors that we are so much disposed to regard the occurrences which take place as the effects of those by which they were preceded. Unfortunately we have not, as yet, any positive or general indications which will enable us to distinguish between that which is simply the effect of a mere succession of time, and that which is produced by another motive power.

A frequent and repeated union alone can authorize us to presume on the connection of two objects, as cause and effect. The oftener this union is repeated, the greater is the probability of this relation being founded on fact. This probability may, at length, become a moral certainty; but this certainty ceases entirely if one of these objects ever appear without the other, for then we should more or less presume that the one is not the only cause of that which is regarded as the effect.

The greater number of facts, however, when we view them in their whole extent, will be found to be the result, not of one sole cause, but of the union of several. If we have nine of these present and the tenth is wanting, the effect will not be produced, and even the contrary often takes place: for instance:—

In order to produce a perfect ear of wheat, we require:

1. A sound grain of wheat, with the germ entire.
2. Some soil, carefully ploughed and prepared.
3. A proper degree of moisture, neither too much nor too little.
4. A proper degree of heat.

All this is generally known, but it is also known that we require:

5. Atmospheric air; for no germ will vegetate in a vacuum.
6. A proper proportion of oxygen; for in air which contains no oxygen the germ will never grow.
7. Carbon; for without it a plant will only flower, and cannot produce any grain.
8. Light; without which the plant exhausts itself, is always weak, and perishes before it arrives at maturity.

All these different substances or agents, and perhaps many others, must be united in order to produce this effect—this ear of corn; and must all unite in their just proportions in order to bring it to perfection. Should the effect not be produced, it arises from some defect in one or other of these causes.

We can experiment either by means of simple *observation*—by examining the subjects and agents placed in relation with each other, and by considering their reciprocal action and observing its results; or by means of *trials*, or experiments—by placing some well known plant in certain situations determined with precision, observing their reciprocal action, and preventing as much as we possibly can any foreign or unknown body from influencing the results of our experiment.

A trial is a question addressed to nature: when such a question is properly put, nature will necessarily reply either yes or no.

It is only within the last century that the art of making experiments has been clearly apprehended. It is on this art that the principal power of man over the material world is founded; and that power will become more extended in proportion as he brings this art nearer to perfection and carries it into full practice.

It is not often that, in an isolated situation, under the very hand of the naturalist, or in the laboratory of the chemist, any complete and satisfactory experiments can take place. They are beyond the active sphere of the agriculturist, properly so called. Nevertheless, the manner of recognising them, of investigating them, and disposing of them, is, as we shall see, of the greatest importance in the science of agriculture.

There is a particular kind of agricultural experiments which have arrived almost at perfection, and which can be regulated with a degree of precision equal to that which is attained in the other practical sciences: these are comparative trials in the open air.

It is true that experiments of this kind are not easily made; but, nevertheless, they are in the power of every reflecting agriculturist. Whoever has accomplished one experiment, whatever may be the peculiarity of the circumstances under which it was made, and has given a faithful account of it, has well contributed to the advancement of science, and consequently to useful practice, and has entitled himself to the gratitude of his contemporaries and of posterity. It would surpass the power of any single individual to accomplish any considerable number of these experiments, and could not be expected from him. It is the duty of the Government to place some well educated men in a position to employ their time and talents in investigating the secrets of nature for the advancement of agriculture and the general good.

Agricultural societies, which are instituted for the advancement of science, should especially engage in the preparation of such experiments, and divide the execution of them among the several members.*

The number of these special experiments being as yet far too small, we are compelled to draw on the large collection of individual observations, imperfect as they are, to adopt them as the principles of our science.

Science would have made much greater progress if the false shame with which agriculturists conceal every unsuccessful experiment, and the exaggerated manner in which they often relate all those in which they have succeeded, had not retarded its progress.†

Natural history, which of late years has been brought to such perfection, renders very valuable assistance in laying the fundamental principles of our science: it affords a clue by which we may extricate ourselves from a labyrinth of imperfect experiments, and serves as a touchstone by which to judge of their truth and their value. Nature acts everywhere on uniform and eternal rules; and the agriculturist can only employ those means which she places at his disposal. It is this disposition which, with reference to agriculture, enables us to derive a physical and chemical knowledge of the precise rules by which it is governed, or at least to obtain indications of the course which we must pursue in all our researches. If natural history only taught us to understand the nature of the soil, the varieties of its composition, and of what substances it is composed, that alone would have been sufficient to throw some valuable light on the numerous differences which are observed in the results of certain operations. These sciences have long exercised an influence on agriculture. Latterly, chemistry in particular has been employed to enrich the science of agriculture; and very great benefit has been derived from this union. We are now enabled to discard several extensively received prejudices, through our more extended observations on the surface of the country, and in rural economy, and to establish the truth of several facts which heretofore were merely probable. It is on this account that scientific instruction in agriculture should always be based on sound notions of physics and chemistry, and that we should endeavour, by means of these sciences, to penetrate as far as possible into the principles and foundation of things; for the want of success in our researches, and the reason that we do not arrive at more numerous and more sound conclusions, is to be attributed to our imperfect knowledge of the phenomena of nature.

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* This plan is adopted by the Royal Agricultural Society of England.

† The author very justly animadverts on the "exaggerated manner" in which practical men have published the results of their experience, which have never been realized in continued practice even by the publishers themselves, and have not failed to throw doubts on all similar propositions. Moderation and caution cannot be too much recommended in such cases.

The agriculturist is principally employed in the reproduction, the vegetation, and in maturing and perfecting the growth of plants. A knowledge of the organization and nature of vegetables, called *physiology*, is indispensable to the study of agriculture; and also a knowledge of their distinctive characteristics, their natural and scientific classification and their nomenclature, or, in other words, *botany.*

And as it is a part of the business of the agriculturist to multiply animals and animal substances, some knowledge of the animal economy, and of the diseases to which it is subject, would be greatly conducive to his success.

No science can be said to be complete without the aid of mathematics, properly so called. But agriculture requires the application of several branches of the mathematics; it demands a knowledge of arithmetic in its most extensive meaning; a calculation for the detailed accounts, and book-keeping.

It is, then, evident that agriculture ought to borrow from every science the principles which she employs as the foundation of her own; and although the sciences do not form an indispensable part of the farmer's education, he ought, nevertheless, to have a general knowledge of them.

## THE BASES OF ENTERPRISE.

An agricultural enterprise requires: 1st, a suitable person; 2nd, capital; 3rd, an estate.

Every person who seeks to practise agriculture with the full success which it admits—and that is the natural aim of every one who engages in it—must possess energy, activity, reflection, perseverance, and a knowledge of all the kindred and accessory sciences.

It is true that it was once considered that the inaptitude which many young men evince for all other undertakings, is a kind of pledge that their proper vocation is agriculture; and we have seen such persons, although continuing in a state of mediocrity, yet deriving much happiness from rural life. But this requires a concurrence of fortunate events that formerly might frequently occur, but which at the present day can rarely take place.

The practice of agriculture is composed of an infinite number of different operations, each of which appears easy in itself, but is the more difficult to execute, inasmuch as they frequently seem to interfere with, and run counter to, one another. In order to regulate them according to the circumstances and powers that are at our disposal, so that no single one shall be neglected, but each performed properly and in its due order, there is required the greatest attention; activity without anxiety; promptitude without precipitation; a care of the whole, united with the strictest attention to the most minute details; a judicious appreciation of all that is more or less necessary, and of that which belongs to different periods of time; an unremitting perseverance in whatever is undertaken, but which, however, does not lead to the neglect of more pressing duties; a prudent estimate of the value of labour and of time, so as to employ them to the best advantage.

As it is impossible that an enterprise like that of agriculture can be exempt from casualties and accidents, a certain tranquillity of mind must be united with the necessary activity in order to secure a happy life. Whether this be attained by the consolations of philosophy or religion, the agriculturist must learn to support misfortune with resignation: he must forget all the evils which it was impossible for him to foresee, all those hopes which have ended in disappointment, so soon as he has, by the adoption of prudent regulations, diminished as much as possible their annoying consequences.

Rural life, in despite of the pleasures that attend it, has so much uniformity about it, and, with all its occupations, has so many hours of idleness, that it scarcely satisfies an active mind, that possesses no other object of employment. In choosing an accessory study, the accomplished agriculturist will not find any one that will be more consonant with his feelings than natural history. He, better than any other person, can abandon himself to the consciousness of living in the bosom of nature, and investigating her sublime laws: and so far from interrupting his usual occupations by this pursuit, he will almost always be able pleasingly and usefully to unite them.

If the moral world and the relations of society too often present us only with the painful spectacle of a resistance to the laws of reason which spreads grief and misery over the earth; nature, on the contrary, unfolds to us more striking proofs of order and unity in proportion as we penetrate into her mysteries. The beauties which we discover, not only gratify our taste, but they also afford us a demonstration that the Eternal Wisdom who unfolds to our view his operations in the material world—who is ever reproducing matter under new and admirable forms—will also in the moral world pursue an equally harmonious plan, the full completion of which is reserved for the ages of eternity. This feeling, although vague, is far more vivid in the inhabitant of the country than in the person who passes his time in populous towns.

It is on this account that more true religion is generally found among agricultural people, than among those devoted to war or to commerce.

The man who feels within himself sufficient talent united with such inclination and taste, or who has manifested such a disposition from his youth, may devote himself to the pursuit of agriculture with a good prospect of success; and, if he acquires a complete knowledge of it may attain the summit of his ambition. Let us now see how this knowledge is to be acquired.

It is, doubtless, most easily and most naturally acquired when the scientific instruction has been preceded by that which is derived from actual observation, from mechanical and practical instruction, or from an agricultural education, properly so called. Nevertheless, we have many examples of men who united inclination with distinguished talents, who, having received a good education, and having previously pursued occupations diametrically opposed to agriculture, have become distinguished agriculturists by means of scientific instruction alone, and have, in a very short time, acquired a superiority over persons who had practised the art for many years and with great success.* Science had opened to them many ways which had been overlooked by those who had pursued the old routine, and had revealed to them with clearness and precision what years of practice had merely shown to others in a vague and obscure manner.

It is true that by far the greater number have, in the beginning, committed some errors in particular cases; they have to pay for their experience; but these errors are attributable to the hitherto defective system of scientific instruction.

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* The author alludes to persons who have not been bred to the art of agriculture, and having adopted that profession, have much excelled the old practitioners, who follow the old routine. Many such instances occur, not only in agriculture, but in many other professions. The mind is free from the bias of early prejudices, exertion is necessary; and when a man is determined to teach himself, it is surprising what the human mind can accomplish. The first step is a conviction that he is in want of learning: the rest will soon follow.

With equal instruction and equal talent, that person will always have the superiority, whose education, good in other respects, has been directed towards agriculture from his early youth.

A young man, fifteen years of age, will obtain the requisite education in an establishment which unites considerable activity in the different branches with the employment of the various means of obtaining the produce of the earth, although this establishment may not have attained the perfection of which it is susceptible. There the pupil will have all the objects and operations of agriculture brought under the cognizance of his senses: he will acquire a practical knowledge of all the details; he will learn to select the proper season for each operation; he will form in his own mind a kind of intellectual admeasurement of the nature and value of soils, the seasons, and of the requisite labour. He will also there be taught all that has relation to the general management and direction of business, and he will carefully observe the manner in which it is conducted as often as opportunity permits. Lastly, he will not fail to acquire, as much as possible, a certain tact in buying and selling.

During more than a century the possibility and advantage of a scientific education for the practice of agriculture has been maintained, and an agricultural chair has been established in almost every university. In so far as it is the duty of these institutions to afford the public functionary, the lawyer, and even the theologian and the medical man, a clear idea of agricultural practice and its importance, I admit the utility of these appointments, and only desire that the instruction shall be directed to the sole end which it can possibly attain.

These professorships, however, do not appear to me necessary or even useful to the agriculturist who seeks instruction there, because the nature of the life which is led there, and the usages of the university, and the general tendency of affairs in such places, seem to possess something altogether foreign to his habits and pursuits, and are calculated to unfit him for the peculiar species of activity and the peculiar kind of life to which he is destined. Besides, it is scarcely to be expected that an agriculturist, who unites practice with science, will accept a professorship of this kind at a university; and he who does not possess both these requisites is by no means fitted for such a situation.

Nothing can contribute more to the acquisition of an enlightened knowledge of agriculture than travelling in those countries which are distinguished for the perfection of their agriculture. The contemplation of practices and institutions so various among different people destroys that prejudice encouraged from our childhood, which leads us to believe that nothing can be done in a better or in a different manner from our own mode of performance. The customs of different provinces and of entire nations, as well in the general proceedings of agriculture as in the performance of individual operations, are, with every thinking man, so many experiments on a grand scale, if he knows how to place them on a level with each other, and to compare their results. But it requires a great deal of perseverance, and the surmounting of many difficulties, to derive real advantage from such travels, and to extend the observation to the actual and true principles of things. They who have only run through a country as it were by post, and who stop only at the inns, will report very little that can be in any way useful. Besides, there would be required a correct judgment, and penetration founded on preliminary and long-continued study, and an impartiality altogether free from prejudice, in order to derive true and positive results from the observations which are made. Without such acquirements, so far from being divested of our preconceived notions, we shall only bring back others still less suited to our climate, and the circumstances in which we are placed.

We shall presently have occasion to add something on the direction of agricultural travels, the best route to be pursued, and, in fact, on the geography of agriculture.

The cultivation of the land attached to a model farm, or other institution for teaching practical agriculture, ought to be a pattern for agricultural practice, but it is by no means necessary that it should be perfect. It is far better that this model should be advancing towards perfection, without having yet attained it, in order the better to show the difficulties by which it is surrounded. It is also necessary that this cultivation should be carried on in the usual manner, and that it should not possess or employ any extraordinary resources which might cause it to advance more rapidly than would otherwise be possible. It ought not to employ in the attempts of improvement any disproportionate or an unusually large capital, nor any resources which would not be generally available.

It ought neither to purchase manure from towns in the neighbourhood, nor to make use of too expensive means of improving the soil, such as an extensive use of the spade; the destruction of perennial crops, or anything of that kind; but the proceedings should be regulated by the strictest economy.

A very limited space of ground would be sufficient to demonstrate what can be effected by the above-mentioned operations.

Such an establishment ought to possess a complete collection of implements and machinery, and every arrangement necessary for the demonstration of the accessory sciences which would be taught there.

The conduct of the pupils, their intercourse with each other, and their proceedings in every respect, should be directed to the great end of the objects of the establishment; not by means of coercion, or by special rules, but by that interest and charm which the subject itself necessarily inspires.

It is in free and unrestrained conversation where the best interchange of ideas and opinions is effected, where these opinions undergo the profoundest investigation, and where they are best freed from the prejudices by which they may have been enveloped. These conversations ought to be encouraged and rendered frequent by every possible means, for nothing would contribute more to the discovery and establishment of the truth than the opposition, not of personal feeling, but of legitimate reasoning, and which will naturally lead to a correct conclusion.*

As scientific education will not from its very nature admit of any external constraint, and can only be consistent with an unfettered spirit, and as it is also to be supposed that those who attend such an institution come to it of their own free will and with the firm determination of acquiring in the most complete manner a thorough knowledge of everything that has relation to agriculture, constraint would be at once prejudicial and useless. On the other hand, those who come or are sent there with any other view should be removed so soon as it is perceived that they are not identifying themselves with the spirit of the institution, and that constraint alone prevents them from infringing the regulations. Nevertheless, in such an establishment there must be certain defined rules which must be strictly observed, if only to ensure the general good, and for the liberty and comfort of every one.. However great the advantage, and certainty these social communications may forward the general object of the institution, they must not interfere with private application or diligence, and therefore each pupil should have a chamber to himself, and his retirement should be undisturbed.

### CAPITAL.

Next to the mental capacity of the person who practises agriculture, capital is the most important consideration; for, with persons of equal talent, the advantage and success is always in proportion to the capital employed. Therefore, next to the incapacity of the agriculturist, the insufficiency of the capital embarked in agriculture is the principal cause of its imperfection.

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* These remarks of the author may be quoted in favour of farmers' clubs; certainly the most effective schools of improvement for the farmer.

By capital we understand everything that, from the special use by the individual, or from its being placed at the disposal of others, produces a revenue or rent. We do not inquire into its origin, or ask whether it has been acquired by inheritance or by labour.

It is true that generally the term capital is only applied to the possession of certain means produced or amassed by labour, but it is sometimes difficult to determine the share which nature or industry has had in the production of certain property; as, for example, in the working of mines and quarries, or of tracts of land recovered from nature by art, and put under cultivation: at other times it is more in relation with the actual state of civilization, or where the land is no longer possessed in right of the first occupant, but only in exchange for some other equivalent capital or property, to consider the soil and the produce of the earth as a species of capital. This latter acceptation of the term will give us the clearest idea of agricultural industry.

The immortal Teraus, in his "Political Economy," (Staatswirthschaft) published by the President of Auerswaldt, establishes, in my opinion, the most correct distinction, when he regards the value of the products of the earth as the wealth of a nation, but as a wealth of which she has not the management. Nowhere have the reciprocal relations of the state of agriculture and of national wealth been treated in a more lucid and practical manner; and I should have entirely founded my ideas on his if I had read that work before this chapter was composed. It will, however, be easy for every reader to adopt his system. As for the results, we shall judge better of them as we proceed.

According to this arrangement, the capital invested in agriculture is of three kinds. 1. Funded property.

2. Capital invested in the farm. 3. Circulating capital.

*The funded property* is that by means of which the agriculturist is put, or may put himself, in possession of landed property. It is the value of the soil or of property already in, or to be taken into possession. According to general usage, and very properly, it includes the buildings and all the other things appertaining to the soil, as well as the rights attached to the domain, and whether or not relating to agriculture.

The landed capital, or the value of an estate, does not always continue the same. It is frequently varied either by external circumstances connected with the value of money and of other things, or principally by internal circumstances relating entirely to itself. The modifications of this latter variation in value are called ameliorations and deteriorations. The capital employed on a farm is augmented by the amelioration in the same manner as by the addition of new funds.

*The capital invested in the farm* consists in the value of the things which are necessary for the exercise of agricultural industry, and is employed in their purchase. It is usually called the *inventory*. Under this denomination are ranged the live stock, and all kinds of agricultural implements and utensils. In some countries they include in the inventory the value of the crops sown, and the advances made for the culture of the following year, and the provisions which remain to be consumed from one harvest to the next. Properly speaking, this latter ought to be considered as a part of the capital which we are next to describe.

*The circulating or current capital* is that with which the domestics and labourers are paid, necessaries of every kind are purchased, the cattle fattened, &c.; and it consists in a sum of money kept for that purpose or in an accumulation of produce which is kept to be converted into money.

It is by this capital that the diminution of that which is invested in the farm is supported, and which from its very nature is always deteriorating; and, lastly, from this capital must be derived the necessary surplus for enlarging the funded capital, and for the improvement of the land.

This current capital forms the motive power of the whole concern; it is by its means that all the labour is effected, and it is from this labour, properly speaking, that the profits of agricultural enterprise arise. Hence it happens that, all accidental successes or misfortunes excepted, and supposing above every thing that the necessary talent and assiduity are employed, the products will always be in direct proportion to this capital.

The funded capital or value of an estate can only be considered as a sum placed out at interest, and on the best security; and it ought to produce the proper rent which can be derived from a capital thus securely placed. Beyond this nothing more is to be expected.

The capital of stock or of the *inventory*, although we admit that it ought always to be kept up to the same amount by the circulating capital, is nevertheless exposed to more dangers than the former, inasmuch as it is subject to certain accidents by which the owner runs a great risk of losing to a greater or less degree, and which has given rise in Germany to the custom of insurance.*

If the interest on the landed capital amounts to four per cent., that of capital employed in the farm ought to be at least six per cent.

The circulating capital is exposed to very great risks; it is the motive power of the whole enterprise, and it requires in the proper administration of it the greatest caution and the most extensive knowledge. For this reason it ought, as the motive power of the whole enterprise, to receive a very high interest, at least 12 per cent.; for it is in this fund that the real profit derived from agriculture consists.

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* Insurance offices for cattle are well known in France; and the agriculturist, in some of the provinces of Germany, owes to them a security which essentially contributes to render the practice of his profession secure, and more easily procures for him the capital requisite for his purposes. The advantages of these institutions appear to me incontestible, if certain prudent and well advised regulations prevent the too frequent negligence in feeding and in the general treatment of these animals. The Mutual Cattle Insurance Society of London now offers the same security to the farmers of England.

Consequently, if a farmer cultivates his own land, he should calculate accurately between the produce of the different funds whence his gross income is derived. He should derive an income equal to the value of the money which he expends on his farm, or which he would derive if he sold the farm and placed the money on other securities. It will be the same with the capital on his farm if he parts with it to any other person on the same risks.

It is impossible to fix any general rule as to what ought to be the just proportion of these divisions of capital relatively to each other. That can only be determined in certain particular cases, and by taking all the local circumstances into consideration. The following only can be received as a general rule: that the person who possesses only a small capital will succeed much better as an agriculturist if he keeps the greater part of it in circulation for the current expenses of his undertaking, and, consequently, does not invest too much of it in land or stock;* for the net produce of the enterprise has less relation to the extent of capital than to the means employed in the profitable application of it.

In England, where mercantile calculation and skill are carried to their greatest extent and pervade every branch of industry and commerce, it is considered that the capital in circulation, in which is always included the stock, should be from seven to nine times the amount of the rent. Whoever takes a farm of £125 rent, should command a circulating capital of from £875 to £1,125. The profits of his speculation, consequently, are not to be reckoned by the rent which he pays, but according to the capital which he can employ; from which it is considered that he ought to derive 12 per cent. profit, which, for £1,125, would be £135 beyond the rent of the farm. If he is the proprietor, he will first deduct the amount of the rent which he would receive from his tenant if he did not cultivate the farm himself, and then he reckons the surplus as the net profit of his speculation. But he will never draw this false conclusion, that since the cultivation of his estate produces him £260, the actual value of his property is twenty-five times this amount. This example shows the error of imagining that any conclusions can be formed of the actual value of any property from its mere produce, although it enters too much into the estimates of most persons. In fact, they endeavour to conceal this error by another, of estimating this produce at a much lower rate than it should be valued at if under good culture. Nevertheless, this vague and deceptive valuation is too frequently adopted, and the consequences of it are extremely injurious to the agricultural interest.

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* The author very judiciously recommends a sufficient circulating capital to be reserved for the expenses of cultivation, and a less quantity of land to be rented, as profit will more generally depend on the mode and success of cultivation, rather than on an extent incapable, or beyond the reach of being properly managed. This is a very general and fatal mistake. The mode of estimating by the rent of land, the quantity of capital that will be necessary for the cultivation, appears very uncertain; for land may be worth 20s. or 40s. an acre, and the farmer will require the same implements and animal strength, the same expence to seed an acre of land, the same farming accommodations, and, very often, more expence in many respects. Some differences will occur in particular points; but a direct ratio between the rent of land and the capital required to stock and cultivate it, has not obtained in our country; and it would lead to the supposition that good land requires more capital applied to produce a greater result; whereas it is known that the same means produces the greater result from the intrinsic quality of the soil. Inferior lands of certain kinds require more capital than rich soils; and the allowance of seven to nine times the rent for capital would fall below any average calculation yet made; and in other cases would far exceed it, except where an extraordinary outlay was required.

Even the capital invested in stock, although its augmentation, generally speaking, adds greatly to agricultural produce, may be extended too far, if, by so doing, the circulating capital be too much diminished.

## THE FARM, AND THE MANNER OF TAKING POSSESSION OF IT.

He who possesses the necessary inclination, talents, knowledge, and capital, and has devoted himself to the practice of agriculture, ought in the first place to obtain possession of a farm.

Whoever wishes to obtain a farm ought, in order to obtain it as advantageously as possible, not to confine himself to any one district, or province, or state, but to look around him in every direction. The more numerous the situations which present themselves, the better will be the chance of making an advantageous selection.

That farm should always be selected which, when every circumstance is carefully weighed, promises the greatest net produce in proportion to the available means of the person who is about to take possession of it. We shall never, at least very rarely, find that a perfectly unexceptionable spot will present itself, or which in every respect will realize the anticipations which have been formed. The chief thing is to be able to judge how far its good qualities surpass the bad ones, and to form a right estimate of the whole, balancing the one against the other. In order to make this comparison in a clear and satisfactory manner, the following method may be adopted. The attention of the young agriculturist having been directed to a particular spot of ground, he must make a satisfactory estimate of its value, by applying to it certain general and invariable principles. Afterwards he must study and duly estimate all the accessory circumstances; he must put a determinate value on the peculiar advantages which may exist independent of the soil; he must value each, on as exact an estimate as possible. On the other hand, all the inconveniences which are attached to the domain must be considered in every point of view, and the difficulties which will present themselves in every great agricultural enterprise. These must also be estimated, and the sum total found. Then, by deducting one sum from the other, it will be seen how far the actual value of the land, according to its extent and to the quality of the soil, is augmented or diminished by these accessory circumstances.

While money continues to experience so many changes in value, it will constitute a very uncertain guide in determining the positive value of the soil. A much more certain and stable guide, and one of universal application, will be found in the produce; which, because it is of universal consumption, always maintains a uniform and permanent relation with every other commodity. This produce is *the grain;* in Germany principally the rye, and in France the wheat. Thus, in order to determine the precise value of a farm, it will be much more correct to say that it is worth so many measures of rye and wheat, than so many pounds or shillings. Or if we wish to reduce this fixed value to a numerical one, which may be modified by circumstances, we must ascertain the medium value of wheat with money in ordinary years; and thus we shall be able easily to calculate the sum that a portion of landed property is worth, according to the actual value of money.

The value of a farm consists: 1. In the extent of the whole and of each of its divisions. 2. In the quality of the soil. This latter quality can only, properly speaking, be demonstrated in a precise manner by an analysis of the different substances of which it is composed, and of their physical properties; this, however, may perhaps be done provisionally, or to a tolerably satisfactory extent, by careful observation of the appearance and of the produce of the soil. 3. In the situation, and in the reciprocal relations of its appurtenances. 4. In the exterior circumstances, the prerogatives, the rights, and the charges of the property; or, in fact, in all its accessory and relative advantages and disadvantages.

In the general examination of the land, the growth of the trees and copses, if there be any on the land, their species, their soundness, the elevation of their branches, and the cleanness of their bark, are among the surest marks of the quality of the soil. The plants which grow spontaneously there, even those that are injurious, afford also a valuable indication; but it is not sufficient that they grow isolated and slowly, but, on the contrary, their increase should be rapid and abundant. Thus the corn or *field thistle (serratula arvensis)*, indicates a rich and productive soil; the butter-bur or great petasites *(tussilago petasites)*, an argillaceous soil; the colt's foot *(tussilago farfara)*, and the bramble, a marly soil; the common chickweed and pimpernel *(alsine media)*, the common sow thistle *(sonchus oleraceus)*, the charlock *(sinapis arvensis)*, grow on soft and tenacious lands; while the wild radish *(raphanus raphanistrum)*, grows in dry and poor lands. The black medick or nonsuch *(medicago lupulina)* is a sure sign of the marly quality of the soil in which it is found.

An abundant growth of grass, by which persons who value estates often suffer themselves to be too much influenced, is a very deceptive indication, as it is often occasioned by a humid atmosphere or by recent manuring, and sometimes even by the bad state of the cultivation.

The appearance of the crops in an early stage is a no less deceptive sign; for, when they are sown thickly, and in the early part of autumn or in the spring, on a bad soil, they may appear, on a superficial inspection, to be superior to those which grow on a better soil. Sometimes, indeed, the corn is sown in a much greater quantity than it ought to be, for the purpose of deceiving the unwary purchaser.

A far more correct judgment of the quality of the soil may be formed by examining the corn in the ear, or the stubble, provided the examination extends to the whole of the farm, and is not confined to one particular field, on which, perhaps, an abundant crop has been produced by extravagant manuring, or by some extraordinary mode of culture which has, perhaps, caused the neglect of some other fields of the farm.

A dark colour of the soil after recent ploughing is one of the surest signs of fertility, except in heaths and marshy lands. A dark colour of the waters in the furrows and of the deposits taken from them is, likewise, an indication of a rich soil.

Practice will soon distinguish by pressure of the foot, or by thrusting a stick into the soil, or even by the sensation which is experienced in passing over the ground on horseback, the degree of tenacity in the soil; whether it consists of tenacious clay, or if it be a yielding soil, or whether sand be the principal ingredient. We may also readily judge of the quality by the state of the clods after recent ploughing, and from noticing the degree of divisibility or tenacity when they have been some time exposed to the influence of the atmosphere; but more particularly the proportions of the soft clay to the gravel may be easily ascertained by rubbing a portion of the mould between the fingers.

The thickness of the layer of vegetable mould may be easily ascertained by thrusting a stick into it, or by examining the sides of ditches where the ground has been lowered. These last, and also mole-hills, discover the nature of the lower strata of the soil.

The scientific agriculturist, who possesses the most precise and accurate ideas of the classification and goodness of the land, and who understands the different relations according to which it should be examined, ought not the less to be acquainted with their ordinary classification, and with the names by which practical men are in the habit of ranging and distinguishing them, whether generally, or in particular districts, in order that he may not be at a loss when he is treating for the purchase of property of this description.

The division of land into good, middling, and bad, is general and natural; but it is purely relative.

Tenacious clay has been often ranked in the first class; and a lighter soil, and even calcareous earth, in the second. Other persons have given the preference, and very justly, to the latter, because, in the cultivation which is associated with pasturage, more regard is paid to the soil which best promotes the spontaneous growth of the herbage; while in the former the growth of corn is the only object regarded.

Sometimes a signification similar to the above is given to the comparative expressions, *heavier* and *lighter;* but these terms are then merely used to denote the tenacity of the soil and the degree of resistance which it offers to the plough and the harrow.

Sometimes the land is classed according to the number of times the seed is multiplied by vegetation in the course of tillage followed in that part of the country; and thus it is called 3, 4, 5, or 6 seed land. Sometimes the seed itself is included in this calculation; at other times it is necessary to become acquainted with the relative quantity of seed that is sown, and whether equal quantities are sown on equal areas of different lands, in order to be able to draw some conclusion from these data; but the produce generally depends more on the quantity of the manure than on the nature of the soil.

One of the most useful modes of classification relates to the description of grain which the land has produced in the course of the established succession of crops, and that, generally, in a period of three years; and likewise to those which it is supposed to be able to produce with the greatest advantage. The following is the classification usually adopted in Germany:—

1. *Wheat land;* that which after a fallow produces wheat with more profit than rye. If, in the course of the triennial rotation, it can bear wheat twice in six years without being manured more than once, it is called—

(*a*). *Rich wheat land;* which is found only in places of alluvial deposits and in low situations, where the rivers have deposited the mud.

(*b*). *Ordinary wheat land,* if it can produce wheat only after having been manured, and after having lain fallow; and the second time, without manuring, rye only.

2. *Barley land.* In this and the following class no attention is paid to the first or winter crop, but only to the second or spring crop. Here are also distinguished—

(*a*). *Rich barley land;* that which twice in six years produces barley after the winter crop, with only one manuring. Many persons, believing that land of this nature can produce wheat equally well for the first crop, include it in the same class with the wheat land. Others, with more reason, draw this distinction, that a soil is often exceedingly well adapted for the production of barley without being well suited to the growth of wheat, and will often bear rye with more advantage. On the contrary, an argillaceous soil, which is better adapted for wheat than for rye, is not so proper for barley, and will, with much greater advantage, be cropped with oats for some one of the second crops.

(*b*). *Poor barley land;* land in which barley will not thrive as a second crop without manure, but which, in the second rotation of crops, may be made to produce oats, though not very abundantly.

Where the large and the small kinds of barley are both cultivated, the lands which produce the first are called *large barley lands;* and the others, the *small barley lands.*

3. *Oat land* is that which produces oats after the harvest of the winter grain. Strictly speaking, only cold and heavy land may be included in this class; and every other soil which yields oats with advantage might, with good tillage, be made to produce barley with equal profit. In general, however, we include under this class lands which are considered too light, or which have too little consistence for the growth of barley. This class includes—

(*a*). *Rich oat land,* which, with only one manuring in nine years, yields oats after each winter crop, and, therefore, three times during each succession of crops.

(*b*). *Middling oat land,* which is allowed to lie fallow the eighth year after it has been manured.

(*c*). *Poor oat land,* which, under the same circumstances, yields but one crop of oats.

4. *Rye land,* which, in the three years' succession of crops, produces rye every third year only, and which has not sufficient strength to produce another kind of grain, and, consequently, must lie fallow for two years.

The names of *sixth, ninth,* and *twelfth years' rye land* is applied to that kind which produces this grain only every sixth, ninth, and twelfth year, and lies fallow during the rest of the time. To this class belong those exterior and distant parcels of land which are never manured, where bad quality does not arise so much from the nature of the soil as from the want of manure. The substance which nature affords to such lands by the growth of the grass and from the dung of the sheep that eat the herbage, is quickly absorbed by the rye crop, and thus the land returns to the original exhausted state.*

However vague this classification may be, it is, nevertheless, the most precise and definite of those which are in general use; it is, likewise, that which is employed as the basis of most valuations. The agriculturist, whose judgment is guided by the most accurate knowledge of the nature of the soil, ought not to be ignorant of it; and he ought, also, in every country to which his fortune may call him, to examine most minutely the physical and chemical properties of every soil, and arrange them under their respective classes.

Every intelligent farmer will be guided in the choice of land rather by the quality of the soil than by the extent of the property; for the want of fertility can seldom be compensated by any increased number of acres. There are farms which are absolutely worth nothing, and which, when every thing is taken into account, never repay the expenses of cultivation; and, consequently, for the growth of corn, a thousand acres of such land are not worth so much as a single acre of good land.

The greater the general fertility of a country, the less is the value of the bad land it contains; for the produce, or the yearly value of the richer land, will diminish the rent of the poorer lands in its neighbourhood. Where the produce of the fertile portion of the land satisfies every want, the soils which are less productive can scarcely be cultivated with advantage. If, on the contrary, the more fertile lands do not produce a sufficient supply for the usual consumption of the district, the cultivation of the others will become more profitable; and, consequently, a higher price may be given for inferior land in a poor country than in one which is highly productive.

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* By land lying in fallow, the author here means a state unoccupied by arable culture; for he mentions the grass sward, and the dung of sheep as being absorbed by the triennial crops of rye, and that the land returns to its originally barren state. This mode resembles the old out-field system of Scotland.

Next to the arable portion of the farms, the meadow land should come into serious consideration. A due proportion of meadow and arable land has hitherto been considered as an essential requisite in a good farm; and that a quantity of land, although composed of the richest and best soil, would be defective if it was not accompanied by a sufficient extent of meadow ground. This opinion is founded on the acknowledged fact that without a sufficient supply of green food no good tillage can exist; and also on the acknowledged axiom, that without meadows there can be no forage. Yet, when it shall come to be generally known that by cultivating the various grasses, and by alternately using the different portions of the land as arable land and as artificial meadows, three or four times as much nourishment can be obtained for the cattle as on the same extent of natural meadows, the deficiency of natural meadow land will no longer be regarded as a defect in an estate, the soil of which is tolerably fertile, and in which the rotation of crops is at the disposal of the farmer.* Nevertheless, this circumstance ought only to be considered as placing some limits to the supposed value of good meadow.

The value of meadows is, perhaps, more difficult to be determined than that of arable land; and fixed rules for the determination can only be laid down when in a portion of this work the cultivation of pasture land is taken into consideration. In most valuations they are divided into three classes—good, middling, and bad; but this division is not sufficiently precise for the correct valuation. The known or estimated produce, and the quantity and value of the hay, would be a better guide; but both the quantity and value vary exceedingly in different times and places. Therefore, the meadow land is divided into five classes; the produce of the first and best being calculated at 30, the second at 20, and the third at 14, the fourth at 10, and the fifth at 6 hundred weights of hay per acre. Particular attention must, however, be paid to the more or less frequent occurrence of circumstances; meadows usually the best watered, being exposed to inundations just at the very time when such an accident will effect the greatest damage. According to the ordinary mode of valuation, meadows are estimated at a price improperly compared with the quantity of hay which they are known or believed to produce. This value arises from the charge for grazing cattle being likewise fixed at too low a rate. Thus, as frequently happens, an attempt is made to conceal one fault by another and a worse.

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* The author steers a middle course in opinion between arable and meadow lands in point of utility. He thinks a knowledge of the alternate system ought to set a limit to natural meadows, but not to annihilate the value; or rather the supposed value. That system will require much time to force its way even with enlightened minds.

The purchaser, agreeably to the knowledge which he has acquired of meadow lands, and of the ameliorations of which they are susceptible at a certain expense, should make an estimate for himself of the advantage which he believes he may derive from it according to his peculiar mode of using it, and from the ordinary market price of the country. He should carefully and personally inquire whether the meadows are exempt from the right of pathway through them; whether they are subject in spring or in autumn to any right of grazing upon them, or any other ancient servitudes; and also whether he can, at his pleasure, irrigate any and what portion of his meadows, or whether he is subjected to any restrictions on this point.

Cattle may be fed: 1. On open spaces, or spots but thinly covered with trees. 2. On fallow lands, or in the stubble of corn-fields. 3. On meadow lands in the spring, and after the first and second mowing. 4. In woods and forests. 5. On marshes.

The valuation of woods is attended with great difficulties. This valuation may be made under very different circumstances, and, consequently, may be attended with very different results: it may have relation to the return which the woods might yield if kept in good order, according to the principles of forest cultivation; or to the sum which might be realized from the quantity of timber actually growing on the land, supposing that the whole or a part of this timber could be profitably disposed of; and also taking into consideration the profit which might be derived from the land thus cleared by converting it to a different use. The difference between the results of these modes of valuation is enormous, especially if the calculation be made according to the method adopted with those which are national property. According to the principles adopted in many estimates, the value of the land would be increased by entirely clearing it of wood and converting it into pasture grounds for sheep.

Timber for building, for other purposes, or for firewood, always adds to the value of an estate; particular attention should therefore be paid to it in the purchasing of land.

Many persons, when about to purchase an estate, place great reliance on the information which they collect from the occupiers of neighbouring farms, or from persons known in the neighbourhood, and even on that which they obtain from the labourers, shepherds, and tenants. Such persons may, it is true, be capable of furnishing useful information; but it would not be prudent to place too much reliance on their reports without testing the correctness of them by actual observation. He who seeks to spare himself the trouble of personal examination, runs great risk of being deceived. Such reports as those referred to are so much the more suspicious in proportion as landed property has become an object of traffic in the country, and has passed into the hands of speculators, particularly those who are connected with mercantile or agricultural companies. The tricks which have been resorted to for the purpose of deceiving purchasers are almost incredible, falling not far short of those practised by horse-dealers. In countries of this character, it will be prudent to regard all those who furnish you with information as tools of the seller, Even written documents, leases, and registers, can scarcely be trusted without some convincing evidence of the truth of their contents.

Sometimes the last owners have sunk large sums of money on an estate, and have considerably augmented the fertility of the soil, but they have not had sufficient perseverance or sufficient good fortune to enable them to reap the benefit of their exertions; and there have been instances in which the improvements have been made on a farm, but it has been left to the successors to enjoy them. On the other hand, the last occupiers may have contrived to reap considerable pecuniary advantage from the use of the property by exhausting the land, and thus improved their own fortunes at the expense of the estate. A farm may thus acquire a good or a bad reputation in the opinion of those who only take a cursory view of it; and this will, in the former case, attract a great number of purchasers to the sale, or, in the latter, keep them away, and thus cause the estate to be sold at a price considerably above or below its actual value. This must not, however, be taken as a general rule; for a needy or a careless occupier may have derived only a scanty amount of produce from the land, and yet have impoverished it to an extent which will render the employment of a very large capital necessary to restore it to a state of fertility.

Estates often possess considerable resources which have escaped the notice of lazy or ignorant farmers, and have, consequently, never been turned to account; and such estates are likely to yield much more than those which have been in the hands of competent persons.

The gross produce of each harvest on a given extent of land having been determined, the net produce may be calculated from it, and for this purpose the quantity of seed sown must first be deducted.

When a calculation of the total amount of the produce has been followed by that of the expenses attendant upon each harvest, it is also customary to deduct the price of the quantity of each grain consumed on the estate (such, for example, as the quantity of wheat and rye for bread, and of barley for beer, &c.), as also the wages paid for threshing the corn. There appears to me to be an unnecessary prolixity about this, since the value of the corn required for consumption on the farm might be more correctly joined with the other expenses of the household, and the result thus obtained would give a much clearer idea of the whole. Besides, it is sometimes necessary to purchase certain kinds of grain, such as oats, for other purposes.

In order to avoid the very troublesome calculation of the expenses of cultivation, attempts have frequently been made to subtract a quantity of grain from the gross produce, in order to cover these expenses and also those of the home consumption. It is evident that this method is exceedingly indefinite, and that it must be considerably modified by time and place.

The term of "*rent or farm grains*" is given to that portion of every kind of seed which remains after deducting the seed sown and the expenses of cultivation, and they are valued in money as constituting the net produce of the culture.

Or, again, the lands comprised in the same class in the register of mensuration or cultivation, may be collected together, divided into three equal parts, and their value arranged in the form of a table.

When there are fields, enclosed by hedges, near the house, they are usually valued separately, not according to the quantity of seed sown in them or the crop which they yield, but according to their extent. Thus, an acre of such land is valued at a much higher rate than an acre of unenclosed land. In the official returns it has even been raised as high as from three to six rix-dollars, although the soil in itself cannot be considered as much better than that of the rest of the land. The more careful tillage, the large quantity of manure with which they are enriched, the right of enclosure, that is to say, the being able to dispense with herding, and the greater quantity of produce which they afford, give a high value to these enclosures in the opinion of most persons.

Kitchen gardens are also valued in proportion to their extent, and at rather a high rate. The great produce derived from them is, however, for the most part due to superior cultivation. The same remarks also apply to hop gardens.

Vineyards are valued according to the amount of the produce. The knowledge of this produce is acquired by practice, and in a manner which it is hardly possible to teach by rule; because the properties of the vine and of the soil, and the influences of climate and aspect, have not as yet been satisfactorily ascertained.

Orchards and fruit gardens require particular attention in point of climate and soil most suitable to fruit. In some countries a good crop may be reckoned in every two years, while in others a good crop can scarcely be obtained once in nine years. In the former there are usually large plantations of fruit trees, and their average produce indicates with sufficient exactness, the price which should be put upon them; in the latter, after having determined the value of the soil, the trees should be estimated only in proportion to their size, vigour, and kind, unless the plantation possesses a certain aspect and situation, be protected from hurtful winds, and contain only trees of a choice kind and of good quality; under such circumstances an orchard may be particularly valuable even in a climate otherwise unfavourable to fruit trees.

As to the expenses of cattle feeding, the principles by which it is determined must, of necessity, be uncertain and subject to variation. In estimates founded on the triennial succession of crops, it is reckoned at scarcely half the value here assigned to it.

In ordinary estimates, the annual cost of a cow is reckoned at from three to ten rix-dollars. But it seldom reaches ten rix-dollars on estates managed according to the triennial succession of crops; and is only found in places where the meadows lie low, are fertile, and well watered. A third part of the stock are considered as *élèves* (young cattle), and each of these is valued at the sixth part of the price of a milch cow. It is, however, admitted that pastures beyond the estate are available for the nourishment of young cattle, and then the produce of one out of two is only taken into account.

Sheep are valued at from twenty to thirty rix-dollars per hundred, and their grazing on sheep walks is not taken into account. Although the profit of sheep husbandry has been allowed to be infinitely greater, it has not been thought necessary to raise the estimate, on account of the great risks from mortality that have hitherto occurred. And in the net produce of sheep feeding, much is undoubtedly attributable to care and industry.

The profit of pigs is sometimes estimated according to the number of cows, and sometimes according to the extent of the grain crops. In the former case, it is considered that for every cow a pig may be kept, which is valued at from eight to ten groschen;* in the latter, one groschen is reckoned for every bushel of winter grain as the value of the feeding of pigs on the stubble. On the other hand, the expenses of feeding poultry are estimated by the extent of the spring sowings; and six groschen for every bushel of seed are allowed for that purpose.

Hunting and fishing can only be estimated according to the locality, or from experience, or from general usage. The valuation of fish ponds requires a peculiar kind of knowledge, which we cannot explain in this place.

Lastly, we have to estimate the value of the statute labour—or that which the tenant is obliged to perform for his landlord without remuneration. This is divided into—

First, statute labour performed by draught cattle and by manual labour. The first kind of statute labour is, for the most part, due only from those estates which were originally sufficiently extensive to require a team of cattle or horses. The other kind is due from small farms, which either are not or were not sufficiently large to maintain teams. Statute labour, by horses, is divided into that which is performed by four horses, and that which is performed by two or only one. As for manual statute labour, it is sometimes due from persons who do not possess any arable land, but merely a house or garden, or some pasture grounds.

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* A groschen is 1½d. English money.

Secondly, into fixed and variable statute labour.

The former is usually limited to a certain period of time, so that the person from whom it is due is obliged to furnish a certain number of days' work per annum. The choice of the time when the work must be performed does not often rest with the owner of the right; the days are more generally fixed in some particular weeks in each period of tillage: sometimes there is a certain amount of each kind of labour appointed for the day, and, at others, the amount is left indefinite. In the latter case the owner of the right derives a very trifling advantage from it, which is much reduced if he has not the power of enforcing the performance of the work, as is the case in places where hereditary service and vassalage have been abolished; and which will be still more the case when hereditary jurisdictions shall have ceased. This statute labour is, in such cases, far more injurious than any other species of servitude, both to the individual who is subjected to it, and to the public good; because it creates idleness and carelessness, intentionally bad performance of work, and a highly reprehensible degree of insubordination; and is thus destructive of morality, and occasions the loss of much valuable time and labour. The servant, or the son of a peasant, is encouraged by his master or his father to be idle, negligent, and deceitful; he considers it as a point of honour to cheat the landlord; he thus becomes habituated to idleness, and then goes on to deceive his master or his father, and himself, by losing the habit or the power of working up to his strength.

From this cause men are found to be more idle in situations where statute labour is established than elsewhere; and the servants in such places imitate the idleness and dishonesty of those who are subjected to this right. For the same reason greater profit is derived from that statute labour, the amount of which is fixed for each day; and it is advantageous to relinquish a considerable number of the days of service in order to obtain this fixed mode.

Sometimes the statute labour consists in a certain quantity of work of a particular description, without specifying the number of days. Under this arrangement the work is certainly more quickly done, but it is not done nearly as well. When all the fields appertaining to an estate, or only a portion of them, are cultivated by statute labour of this kind, they may easily be distinguished by the scanty crops even from the lands of the peasants; and notwithstanding the advantages resulting from considerable tithes and extensive pasturages, they often yield a very poor return. In such districts, lands thus cultivated may be distinguished, even by a very casual observer, from those cultivated by the servants and teams of the proprietor. The difference in the produce amounts to far more than the value of the statute labour.

If, then, the amount of the labour is to be fixed, either by the day or by the aggregate, the best mode of proceeding is to make choice of work, the manner of executing which shall not cause any sensible difference; and thus, as far as possible, it is desirable to use carts and waggons, the loading of which can be determined with tolerable precision.

Undefined statute labour appears to be only compatible with the condition of the peasant, whose house, farm, and cattle, are the property of his landlord; who has thus the right of continuing or withdrawing them at his pleasure. In this case the peasant must be literally regarded as a servant, who is allowed the use of the farm in lieu of board and wages. The landlord will not, of course, overwork either the peasant or his cattle for fear of injuring his own property. This arrangement may take place independent of vassalage or hereditary servitude, the parties having the option of cancelling their mutual engagements at the termination of a specified time, if they find it advantageous to be done. Statute labour, of this nature, still exists in places where the peasant is really the owner of his farm. In such cases unreasonable demands are restrained by the principle that the peasant ought to have sufficient time allowed him to sow his own land, and cultivate his own farm; but as the decision of disputes which may arise on these points is attended with infinite difficulty, law-suits and misunderstandings without end arise, the annoyance of which is scarcely compensated by the advantages which may be derived from such services. Personal statute labour is sometimes regulated by the day, and sometimes by the quantity and nature of the work. To the latter kind belong, particularly, the seed time and harvest statute labour, in which any certain person has to execute a fixed quantity of work. In daily statute labour, it is frequently not specified whether the work is to be done by a man or a woman, by a strong or a weak person. But as it is generally performed by persons who are otherwise most frequently employed on the estate, and who are, consequently, more dependent upon it, and sometimes also by tenants, who pay their rent in this manner, greater advantage may be expected from it than from statute labour by horses; and it may, without risk of error, be estimated at the value of a woman's day's work. This kind of service is likewise less burdensome to the individual from whom it is due. In some places it is the established custom to have the entire harvest gathered in by labour of this kind, in return for which the labourers receive a certain portion of the crop, and after the threshing, a second remuneration in grain.

However advantageous this practice may have appeared, the inconveniences are now fully appreciated in Lower Silesia; not so much on account of the excessive quantity of the produce which the labourers receive, as from the irregularity and carelessness with which the harvest work is performed. These hereditary harvest labourers are now regarded rather as a burden than an advantage to an estate.*

Another important point to be attended to in the purchase of an estate, is the relative position of the lands of which it is composed. In some countries the division and mingling together of properties of various kinds, and belonging to different parties, is almost universal. When the partitions were first made, the method of dividing a given extent of surface into any number of equal portions was unknown: that ignorance was undoubtedly the cause of this dismemberment of estates; it may, however, have arisen partly from other considerations, which were then of more consequence than the appropriate situation of a field. At the present day, where this excessive division of the estates cannot be modified, it totally precludes the possibility of bringing the land to any degree of fertility. The cultivation of such land is subjected to a number of difficulties and annoyances, and the small portions of it can never be so well cultivated as the larger. Great loss of time is occasioned by the fields lying apart from one another; and besides, such a division of the land renders it impossible properly to overlook the workmen, or maintain a fitting control over them; neither can an exact account be kept of the work that is done; nor can the time and labour which will be required for tilling and sowing the land be previously determined. The separation of the fields by ditches occasions the loss of a considerable quantity of land; and yet these ditches are necessary if we wish to have the boundaries preserved inviolate. Moreover, without the concurrence of his neighbours, the farmer is unable to effect the destruction of noxious weeds; and proper enclosures, which are often so useful, become impracticable.†

On this account detached portions of land, as those in question, are, in the opinion of experienced agriculturists, scarcely of half the value of those estates where lands lie together, and which the proprietor can use without restriction. An experienced agriculturist will, therefore, always decline purchasing an estate consisting of detached portions, unless he has a fair prospect of being able to make some exchange, and so unite a considerable part of his land in one tract; and enclose it, and enjoy the full and entire control.

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* The disadvantages of statute labour of any kind are here treated at length, and the total abolition is very earnestly urged. The late commutation of road labour in England may be regarded as the last vestige of that injurious system. Many remnants of it yet remain in the northern parts of the kingdom, but are gradually falling into disuse.

† How perfect a picture of the evils of our common field system.

When an estate is composed of contiguous portions of land, or, at least, contains enclosures, or considerable pieces thus united, it is then necessary to consider it as a whole. The nearer it approaches to a circular or a square form, the more commodious it will be; a long and narrow strip of land is very inconvenient, and is not easily and suitably apportioned to the successive crops.

Another important subject of observation is, that the buildings belonging to the farm should be, as nearly as possible, in the centre of the property, and at an equal distance from each portion of it, if the lands can be so divided that they shall all immediately surround the buildings, and that the remotest part of one field shall not be more distant than the remotest part of another.

Injudiciously situated farm houses, barns, &c. &c., are but too frequently met with on estates; because, at the time of the erection of the ancient chateaus, convenience in tillage was the last thing that occupied attention; and, latterly, entire farm houses have rarely been erected, but merely a few isolated buildings, which have been, for the most part, placed on the same spot as the old ones, in order to be in accordance with those already erected. This evil can seldom be remedied, except by the erection of entire new farmsteads; and there are not often sufficient motives to induce such a determination. This is a point to which particular attention should be paid when purchasing an estate.

The roads which lead from the buildings to the land, or from one part of the estate to another, should also be carefully noticed; since, if they are badly contrived, rough, and circuitous, they will occasion a great waste of labour and of time. The purchaser of an estate must not forget to calculate the alterations and repairs which these roads may require.

A judicious arrangement and due proportion of farm buildings, is a valuable feature in an estate.

The farm buildings are generally omitted in a valuation, being regarded as a necessary part of an estate. But the purchaser should not fail to regard their being out of repair, badly situated, &c., and the expenses necessary to remedy these evils as very disadvantageous circumstances.

Good and substantial buildings should always be considered as having a certain value, although he who calculates the interest and compound interest of his outlay, may not be inclined to include them in his valuation.

A plentiful supply of good water in the farm yard, and in every place where it can be turned to good account, is a matter of great importance; and the advantage of which is rarely appreciated, excepting where it is wanting.

Perfect equality or resemblance in the arable lands, provided that the soil is tolerably moist, and easily worked at all times, facilitates the distribution of the portions of land appropriated to the different crops, and, consequently, the whole management of the farm. Numerous and considerable variations in the nature of the soil create and give rise to considerable difficulties in the choice and distribution of the various successions of the crops, and which require more than ordinary experience and sagacity to overcome. If, however, the soil be of a bad quality, it is desirable that the defects should be in opposite extremes. If one part of the land consist of clay, which is so tenacious as only to admit of tillage in that dry state of the atmosphere which is never of long duration, it is important to possess a proportionate extent of light soil, which may be worked in any state of the weather; and this land, in such cases, acquires a peculiar value, because it affords employment for the labourer and the teams when the state of the argillaceous land will not admit its being tilled; and, therefore, when the favourable degree of temperature arrives for working these latter portions, the farmer is able to expend on them a greater proportion of labour and care.

Among the circumstances which determine the relative value of an estate, the commercial relations, and every thing connected with them, demand especial attention. In this respect, the geographical position is of great importance. The neighbourhood of large towns may double or triple the value of the soil, to an agriculturist who is inclined to speculate, and who knows how to turn it to account. The greater or less distance of the principal market towns and sea-ports, may also considerably affect the value of the land. In most valuations, the price of corn is usually regulated by these circumstances. Communication with these markets and sea-ports, by means of canals and navigable rivers, or, at all events, by good roads, which are always passable and not encumbered with heavy tolls, diminishes, as it were, the distance of an estate from them, by lowering the expense of transporting the produce.

The demand for different kinds of produce is infinitely more advantageous to an experienced agriculturist than that which is confined to a limited number of varieties. He is then able to apply his land to the growth of all the various kinds of produce for which it is adapted, to intermix them and let them succeed one another at more distant intervals; whereas he is much more restricted if the demand be limited for grain alone. In most cases a high price of *live stock* is far more advantageous to the farmer than a high price of corn, because he can raise a proportionally greater quantity of live stock than he can of vegetable produce for the market; the latter being in part, at least, consumed on the land, and the price of labour is regulated by the price of corn rather than by that of flesh, wool, &c. But special attention must always be paid to the most economical way of procuring the manure which so materially affects the growth of plants and of vegetable produce.

The constitution of a country, and the principles by which it is governed, have likewise an important influence on the value of an estate. A firm, precise, and intelligible code of laws, a simple and expeditious form of conducting law suits, and a rigidly impartial administration of justice, tend to raise the value of property in the opinion of every reasonable man.

A well devised and efficient system of domestic and rural magistrates and police, which affords protection against thieves, and, as far as possible, guards against every kind of danger; which lightens the duty of assisting the poor, and although obliged to supply the want of public spirit by coercive measures, yet abstains from the imposition of vexatious imposts; which, disregarding all antiquated prejudices, acts upon reasonable principles and not upon ancient forms; and which is, finally, more solicitous for the establishment of order than for the profit arising from the settlement of disputes; such a magistracy and police cannot be too highly valued. A consistent and rigorously observed system for the regulation of servants is also peculiarly important.

A government which recognises and adopts this principle, viz., that the improvement and culture of the soil to the highest possible degree, contributes more than any thing to the welfare of the country, and to the strength and riches of the state; and that all other considerations of political economy must, therefore, yield in importance to the necessity of promoting the increase of produce; a government, which recognises and acts upon this principle, will, by so doing, add considerably to the value of land, and induce foreigners to invest their capital in it.

The more numerous the population of a country, the greater is the value of the profit to be derived from the cultivation of the land. These advantages are, however, greatly influenced by the nature of the population, the power and relative proportions of the classes of which it is composed. A large population in towns is highly advantageous to the agriculturist in a mercantile point of view, as it ensures the demand for a great quantity and variety of provisions.

Property, or land, is either absolute, acquired by inheritance, or purchase, and is then called patrimonial, or freehold; or it is limited, as is the case with that in which the occupier has a life interest, or holds by a long lease, or an hereditary lease, or in various other ways sanctioned by custom. The restrictions on the free disposal of property of the latter description are many and various; in different countries, and in different provinces of the same country, they will be found to be more or less burdensome and oppressive. Before deciding on the purchase of an estate, all possible information should be obtained respecting the origin of these restrictions, and the laws and usages which relate to them. But since, at the present day, most governments seem to be aware of the great inconveniences that arise from restrictions on property, there is a prevailing disposition to abolish them and to enfranchise all estates by the substitution of fixed duties. Such a measure will restore a value to many properties which they had almost totally lost, and which will contribute greatly to general convenience.

There are a number of particular rights to which an estate may be entitled, or to which it may be subject, and which must, therefore, be taken into consideration in forming a valuation of it; as, for example:—

The right of cutting timber *(droit de bochérage)*, or of taking wood for building, repairs, or firing, from the forest of another party. This right is sometimes unlimited, as regards the extent to which the owner may avail himself of it; at other times it is more or less restricted.

The right of mast *(droit de glandée)*, or that of feeding pigs in another man's forest. This right is also frequently unlimited; but it is generally restricted to a certain number of animals. It usually does great damage to the forest.

The right of way *(droit de passage)*, which confers the privilege of demanding a road or path through the estate of another, the direction of which may either be fixed, or removable by the will of the proprietor of this right. The breadth of the carriage road should be eight feet, and, where any windings occur, ten feet; and it must be wide enough to give a free passage to a harvest waggon.

There are also simple rights of pathway *(droits de sentier)*, which are sometimes very expensive and burdensome to the proprietor, and the establishment of which ought, therefore, to be strongly opposed.

The same may be said of the rights of pasturage, and of watering cattle on another man's estate *(droits de pacage et d'abreuvage)*, which often hinder or prevent the cultivation of a considerable extent of ground.

The rights of conducting and using water *(droits de passage et d'usage d'eaux)*, give to the owner the privilege of making arrangements for water-courses, drains, ditches, and sluices on the lands belonging to another, and care ought to be used that they shall not occasion greater damage or inconvenience to the proprietor of the estate than the nature of the case renders indispensable. With regard to the right of turning waste water upon a neighbour's land, the provincial regulations vary exceedingly. This often makes a very great difference in the value of an estate, because it may be rendered healthy or unhealthy, according to the manner in which the right is exercised.*

The most minute examination of all the details of these privileges and restrictions would be inadequate to the determination of the exact pecuniary value of an estate; such an examination may, however, serve as a guide respecting the expediency or inexpediency of purchasing some particular estate. After having determined the value of the land, independent of all other or secondary considerations, it will be best to proceed according to the method proposed in a previous page, to estimate every other advantage or disadvantage, in order to add or deduct its value; and an opinion may then be formed with regard to the expediency of giving more or less for an estate than the intrinsic value of the land.

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* The different rights and burdens on landed property enumerated by the author as being hurtful and injurious, are as many remnants of feudal ignorance, and are now, or ought to be, abolished in all enlightened states.

### *Leasehold Estates.*

The second manner in which a person may get possession and hold an estate, is by *lease*. This is the purchase of an estate, or of its produce, for a certain number of years; it relates to purchase in several ways. The search for an estate suitable to the means and industry of the farmer, and the examination and estimate of its qualities and value, should be conducted in the same manner. But there are considerations relative to farming, which are not only different, but totally opposed to these directions. There the proprietor directs or ought to direct all his efforts to the obtaining and continually increasing the quantity of produce, or to the constant augmentation of its real value. The farmer can have no aim beyond obtaining the greatest possible amount of produce during the term of his lease, without troubling himself about the value of the land after its expiration. While the proprietor may content himself with a scanty produce during the first few years, with the view of securing a larger and more permanent crop in future, the farmer must, on the contrary, endeavour to obtain the largest possible crop, even at the risk of diminishing the amount of produce during the latter part of his lease. The proprietor, who acts the part of a prudent agriculturist, derives both pleasure and profit from applying all the capital and means which are at his disposal, to his estate; whereas the farmer draws from the estate all the capital and profit that he can, in order to employ it elsewhere, or place it out at interest.

The proprietor delights in improving his estate; the farmer only endeavours to augment his fortune.

The longer, therefore, the term of a lease, the more nearly will the interest of the farmer coincide with that of the proprietor; and the shorter the term, the more widely will the interests of the two parties diverge.* A farmer who holds a lease for twenty-four years will, if he acts prudently, follow the same course for at least the first two-thirds of his lease, as would be pursued by the proprietor. But the time will arrive when he will be guided by totally opposite considerations, and will be obliged to draw from the land precisely in proportion to the money which he has previously expended upon it.

Besides, we must recollect that the farmer has not the means, even if he has the will to do so, of expending so much upon the land as the proprietor himself. He must pay his rent every year; while the landlord who enters with spirit into the undertaking, can save something from the net profit to expend upon his land. The former may be compared to a merchant who trades with borrowed money, the latter to one who speculates with his own capital. The former must make his being able to pay the interest of what he has borrowed, the first consideration; the latter may think of extending his commerce and undertakings by new speculations.

It is not then to be expected from a farmer whose tenure is very short, nor according to the principles of his occupation can it be required of him, that in the cultivation of an estate he should act as if it were his own property, or sacrifice any part of his profits, even for the sake of improving the land very considerably.

For these reasons it has been thought necessary to impose certain conditions on the farmer which may restrict him in the management of his farm and compel him to conduct it in such a manner as shall contribute to the improvement of the land. But the drawing up of such contracts is an exceedingly difficult matter; so much so, that there is perhaps some reason in the assertion, that if all the most skilful lawyers and best agriculturists in the country were to meet together and be employed for a month in the formation of one single farming lease, they would not be able to concoct one which would secure the estate from the deteriorations caused by a bad farmer, without making the contract such as an honest man could not accept. If the conditions were too precise and binding, a man who united prudence with honesty would reject them: he would leave the farm to be leased by some simple-minded individual, or by one who has his own peculiar mode of going to work.

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* The author's views of leasing land are most just and liberal; for the nearer the holding of land by the farmer is assimilated to that of the land owner, the closer will the interest of both parties be associated.

Even if the rent of the farm should be such as to enable him to observe these conditions, the farmer would, nevertheless, find all his exertions fettered, even those which he might be willing to engage in with a view to the improvement of the land; for in every undertaking, even the most useful, which might deviate in the slightest degree from the line of conduct marked out for him, he would be in danger of subjecting himself to censure and legal processes.

On the other hand, a farmer who is satisfied that by keeping to the letter of his contract he can save himself from being prosecuted in a court of law or condemned to pay damages greater than his profits, will always be able to evade the conditions of a lease filled with legal precautions, especially if in laying down the conditions the greatest possible care has not been taken to attend to the peculiar circumstances of the estate. He will always find the means of evading oppressive conditions and restrictions, or of securing compensation for the fulfilment of them in some manner still more detrimental to the property.

With the view of placing in a clearer light the maxims by which dishonest farmers are in the habit of regulating their practice, and of putting those who let farms on lease on their guard against them, we shall here transcribe *the golden alphabet of the farmers who have placed themselves above the laws of duty and honesty.*

1. Above all things look out for a farm which has been brought into good condition by proper and improving cultivation, or by having had its resources but little exhausted. For such a farm you may, in propor-

tion to its extent, pay double the rent, for a small number of years, which you would give for one which has been impoverished by an avaricious agriculturist or by industrious farmers. In the former you may employ the utmost refinements of the art of exhaustion; whereas, in the latter, you will be obliged to adhere to the ordinary mode of proceeding.

2. If possible, cultivate no grain except for sale; do not raise anything for the consumption of cattle, because they do not immediately pay the expenses of better feeding, and you would not be able to derive the full advantage of the quantity of manure which you would have put on the ground during the short term of your lease.

3. Among the fallow crops, cultivate those only which produce the greatest profit in money, as flax, tobacco, seeds which produce oil, &c.; and if you cannot undertake their cultivation yourself, let the ground to poor people in the neighbourhood who will pay you partly in money and partly in produce. Never mind if they do not give you any straw, for the farmer is generally prohibited from selling it, and at all events you could not venture to sell it openly in large quantities.

4. As these crops require a great deal of manure, and you will every day obtain a smaller quantity of that article, content yourself with raising them on those fields which are in the best state of cultivation and at the smallest distance; and thus the cartage will occupy less time. Even if the other fields should be unable to produce anything during the latter years of your lease, you will be sufficiently indemnified for this miscalculation; and you will have a right to complain of the sterility of the soil, and to demand a reduction of rent. Besides, the nearer portions of the land are most likely to be noticed by the landlord and by strangers; and if any one should say that flax, rape, and tobacco exhaust the land, you have only to appeal to the fine wheat growing close by. Never expend manure upon the fields which are most in need of it, for poor land never pays the expense of the first manuring; you can, however, put a little on the

sides of the fields, and near to the pathways. In the last year of your lease, apply the manure as much as possible to the spring crops, because you will reap those, but you will not reap the autumnal crop.

5. During the first few years, give the land the best possible tillage with the plough, the harrow, and the roll, in order to destroy all noxious weeds, to bring the manure which the soil may already contain into action, and to divide the clods so that the roots of the plants shall find nourishment in them. Therefore, increase your teams, and you will be repaid for the outlay before the expiration of your lease. But towards the end of the lease you must relinquish this perfection of tillage so as to be able to diminish your teams, or to employ them in other occupation which will yield greater profit. As far as possible, at this time, sow your seed after one or two ploughings; and let your ploughshares be very broad, so that you may be able to make furrows twelve inches wide. You need not trouble yourself about ploughing the land to sow seed from which you will not gather the crop, it will be much more to your advantage to make merely a secondary operation of it.

6. It is a great advantage to be allowed to plough up old grass land and root up plantations. In seeking for a farm you should always endeavour to obtain this privilege. But in such a case, from the very commencement, direct all the means and powers you have at command to the undertaking. The lands thus brought into a state of cultivation, will produce at first fine crops of corn for market, and will afterwards, without manuring, continue to produce inferior kinds of grain until the end of your lease: it will matter little to you if they should then be completely exhausted.

7. Do not trouble yourself about the meadow land, excepting so far as is necessary in order to obtain fodder for your teams; for it does not repay the expense of management. If, towards the latter end of your lease, the meadows should have become marshy from want of drainage, or from the ditches being choked, or should be

covered with thorns and bushes, or broken by mole-hills, and on account of these defects yield a small quantity of hay, and of an inferior quality, you need not concern yourself much about it, it will make little difference to you, as you would otherwise be prevented from disposing of your hay.

8. If you have taken the stock upon lease at a valuation, and have to return it in the same manner, remove all the best horses, oxen, and cows, and replace them by inferior animals, or otherwise pay the deficiency in money. In valuations of this description, good stock are always estimated at a proportionally lower rate than bad, and the latter look less miserable when the good are not placed by their side. Towards the end of the lease, do not put the bull to the cows, or, at least, do not let it be done until a very late period, in order that the cows may not have calved before the time of returning the stock; they will then appear to be in much better condition, even if they have been badly fed. The continuance of the profit of the cows which are not in calf, will fully compensate you for the loss of the surplus that those which recently calved would have afforded you. You should likewise include all the old harness and farming implements in the valuation, keeping all that which is no longer serviceable for this purpose, and having it repaired and put in order: as to the new, you may put it on one side. A miserable-looking stock often inspires those who value it with compassion for the farmer, and inclines them to treat him leniently.

9. It is, of course, understood, that you must not go to any expense in order to keep the gardens, ponds, and buildings in order: the landlord generally takes upon himself all the larger repairs at the end of the lease; it is, therefore, your interest to allow the small dilapidations to become large ones.

10. Exact all that the laws and customs will allow from those who owe you statute labour; it will not matter to you if they are ruined.

11. If the landlord should reserve any part of the

produce for himself, and fix a high price on it, because it is the growth of his own land, and, consequently, offer you a considerable reduction of rent in return for it, agree to his proposal by all means. It is true that you will the sooner be at issue with him; but that would happen under all circumstances, especially if he resided upon the estate; and, besides, it can be of little importance to you if your lease is properly drawn up. If it should prove injurious to you at first, you have only to contrive to enlist on your side the servants who receive the produce for the landlord.

There are, undoubtedly, farmers, whose known character is a sufficient security to the landlord that they will not be guided by such maxims as those just quoted. There are some, too, who are such enthusiasts in agriculture that they will even sacrifice their own profits for the sake of attaining perfection. But men of this class are not very numerous; indeed, it is unreasonable to expect, even from an honest man, that he should, as a farmer, expend money upon an estate unless he has a very fair prospect of being able to recover it. That which does not improve, will certainly degenerate; it is, therefore, very seldom that a farmer does not leave an estate in a worse condition than when he took possession of it.*

The case is different with regard to lands which are government property; in some states these domains are farmed out for very short periods, but upon very liberal terms. According to the system pursued by these governments, the farmers are sure of a renewal of their leases, provided they act honestly and submit to the new valuations, which are always conducted on very equitable principles, and with a due regard to the improvements which the farmers have made upon the land. Sometimes, indeed, a more than ordinarily good management of their farm may justify the tenant in expecting to receive a better one, and to be able to leave it as an inheritance to his family. A man who holds his farm upon such terms may regard it almost as his own property, and act accordingly in all the departments of his management.

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* The editors feel that happily for the character of the great mass of the farmers of England, these remarks do not apply to *them*.

Under such conditions, the government lands have, no doubt, been saved from deterioration, although at the sacrifice of a considerable portion of their net produce.

In those states, on the contrary, in which the lands have been let to the highest bidder, without regard to his personal character, and a higher rent obtained in consequence, all the contracts, all the clauses introduced into leases, and all the restrictions to which the tenants have been subjected, have not been sufficient to preserve the land from serious deterioration, and, in spite of the continuance of the high price of corn, occasions a considerable diminution of rent as well as of produce.

It is quite out of the question to expect that the farmer will undertake those more extensive improvements which tend to produce a permanent increase in the value of the land. Nevertheless, the opportunity of making them occurs so often, and the advantage attending them is so obvious, that both parties ought to be disposed to favour the adoption. It might be laid down as a rule that the landlord should furnish the necessary capital, which should be fixed at a certain sum; and that the farmer should pay him interest for it, at the rate of ten per cent., during the remainder of his lease. Under such an arrangement, the farmer would never propose any improvement, of the utility of which he was not well convinced; and the landlord would only have to consider whether the improvements were likely to be permanently beneficial to the estate.

With respect to repairs, it seems the most equitable manner would be for the landlord to furnish the materials, and the farmer the labour. The most absurd regulation which could well have been adopted, was that by which all the small repairs should be made at the expense of the farmer, and the large ones at the expense of the landlord.

### *Hereditary Leases.*[*]

An hereditary lease has the peculiarity, that it ensures to the tenant as much freedom in the use of the land as if it were his freehold property; and to the landlord, under certain proper conditions, a certain rent, independent of all risks, and subject to no diminution whatsoever.

The most important point, with regard to this system, is an accurate determination of the value of the land, or of its produce, after having deducted all the necessary expenses and a fair profit for the farmer. But as money has only a nominal value, and that value is constantly varying, it is most important that the value of the land, or its rent, should be determined not by money but by corn, the average value of which, with regard to other things, has for some time been fixed and will long continue in that value. It is true that this standard varies from year to year, and is for a short time even more variable than the value of money, but never for a long continuance; the value of grain preserves a constant ratio with that of all the real necessaries of life, because it is, in a great measure, the standard by which the price of labour is regulated.

For this reason the rent of hereditary farms, and of those which are held on long leases, should be calculated according to the quantity of corn usually grown in the country. It should not, however, be paid in kind, because then the rent would sometimes be very high and sometimes very low; but it should be paid in money, by the average rate of a number of previous years.

Moreover, a deduction should be made for those years in which the crop has failed, or in which, from this circumstance or others, the corn has risen to an unusually high price; because, in spite of the high price of corn in those years, the agriculturist must have incurred some loss, and the recurrence of similar circumstances is neither to be expected nor desired. Thus, it would be absolutely unjust to fix the average price according to those which have been obtained during the last ten years, in which the various crops have been below the usual average, or the prices have been still further increased by other accidental circumstances. By such a mode of reckoning it is more than probable, that in the course of a few years the farmers or tenants would soon be brought to ruin.

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[*] A kind of *emphytéose*.—FRENCH TRANS.

The following objection has been made to the system of valuing the rent of a farm according to the produce, that as the price of produce is liable to increase and diminution, it is impossible to be certain of a fixed rent. But this objection is altogether unfounded: the real value of corn remains the same, it is the nominal value only which is liable to variations and change.

The advantages of hereditary leases are manifold and striking; hence, there is no doubt that at the present day, when more enlarged views are becoming prevalent, this system will soon be universally adopted, especially in those districts in which estates of considerable extent have been preserved; and also that other estates which have hitherto been farmed out for uncertain periods, and on conditions more or less burdensome to both landlord and tenant, will speedily be brought under the same system.

## SECTION II.

## THE ECONOMY, ORGANIZATION, AND DIRECTION, OF AN AGRICULTURAL ENTERPRISE.

The word "economy" has latterly been used in various senses; the Germans give it a very indefinite signification.

Judging from its etymology and original signification, the Greeks seem to have understood by it the establishment and direction of the *ménage*, or domestic arrangements.

Xenophon, in his work on economy, treats of domestic management, the reciprocal duties of the members of a family and of those who compose the household; and only incidentally mentions agriculture as having relation to domestic affairs. This word is never applied to agriculture by Xenophon, nor, indeed, by any Greek author; they distinguish it by the terms, *georgic geoponic.*

The Romans give a very extensive and indefinite signification to the word "economy." They understand by it, the best method of attaining the aim and end of some particular thing; or the disposition, plan, and division of some particular work. Thus, Cicero speaks of *œconomia causæ, œconomia orationis;* and by this he means the direction of a law process, the arrangement of an harangue. Several German authors use it in this sense when they speak of the *œkonomie eines schauspiels*, or *eines gedichtes,* the economy of a play or poem. Authors of other nations have adopted all the significations which the Romans have attached to this word, and understand by it the relation of the various parts of any particular thing to each other and to the whole—that which we are accustomed to term the *organization*. The word "economy" only acquires a real sense when applied to some particular subject: thus, we hear of "the economy of nature," "the animal economy," and "the economy of the state" spoken of. It is also applied to some particular branch of science or industry; but, in the latter case, the nature of the economy ought to be pointed out, if it is not indicated by the nature of the subject.

In speaking of agricultural management, the French say, *l'economie rurale*, and the English, *rural economy;* and yet neither the one nor the other intend thereby to signify the absolute execution of agricultural operations, but only the division and circumstances or appurtenances of agriculture. In Germany, where a Latin or Greek name has lately been thought to give dignity to a science, and has, consequently, been introduced into the title of most of the scientific works, some authors have begun to term, not only the science of agriculture, but agriculture itself, the *oekonomie;* and the word is used exclusively in this sense by many persons. It is for this reason that those who are supposed to practise the art with the greatest skill and science, are termed *oekonomen* (economists); and that some of those who are employed in superintending the labourers, even though they frequently have not the least idea of the actual principles of agriculture, chose to be designated by this title.

But this word has likewise been employed in another sense, and one not less foreign to it. As it is evident that the principal object of skilful economy is to attain to some particular end at the least possible expense, they have given the term "economy" to frugality—taken, first, in its widest sense; and, secondly, in its more immediate application to money: and some have even gone so far as to comprehend avarice, although it should fail of attaining its end; and have called those who devote nothing to advance their agriculture, but, on the contrary, exhaust and ruin it, *good economists.*

Attention to receipts and expenditure has also been termed "economy;" and those who had the management of religious societies were termed "economists." We shall adopt the Latin signification of the word, and, when using it with reference to agriculture, simply imply that part of the science which teaches the most advantageous proportions, and that direction and application of the means which will be most likely to tend to facilitate and increase reproduction. This section, therefore, will treat of the establishment, the support, and the use of the powers by which labour is carried on; of cattle, or rather of the relation which exists between fodder, manure, and agriculture in general; the necessary division of the fields, and the various systems of agriculture considered as the means of approaching, in each locality, as nearly as possible, to the aim of the undertaking, that of deriving from cultivation the highest and most permanent net produce; and, lastly, of the direction of the whole, and of its transcription into registers, diaries, and account-books.

### LABOUR IN GENERAL.

From labour man derives or has derived all that he possesses. That which the soil produces without labour or cultivation is very trifling, and can only be taken into consideration in a wandering life.

We are indebted to labour for every kind of food, every comfort, and every luxury; for riches; and even for the capital necessary for carrying forward any branch of trade or science. It is the quantity and quality of the labour applied to any particular thing, which determines its value or natural price.

All labour requires, however, a matter or subject to which it is applicable. The soil is the matter furnished by nature for agricultural labour, and the products derived from it by this labour may be derived from all other matter by the application of the requisite industry.

It is not entirely and strictly right to suppose that all riches and the whole revenue of the nation arise solely from labour: the soil forms a considerable part of it. While, on the other hand, those who regard the earth as the sole source of every revenue, far exceed the actual fact.

A nation, inhabiting a very fertile country, will be able to raise itself to a state of ease, if not of luxury, much sooner than any other; but it too often happens that the fertility of the soil and the fineness of the climate render the people indolent, and indisposed to profit by these advantages.

Without cultivation, the soil will not produce anything; and it is that alone which gives to it the actual value. In the infancy of nations, each person took to himself as much ground as he chose to cultivate, without paying for it; because the country was not sufficiently populous to make this appropriation objectionable. But no sooner was the value which the soil may derive from cultivation perceived, than the chiefs and sovereigns took possession of the land and affixed a price to it. This price continued to be very low so long as there were not sufficient labourers, or science, properly to direct and carry on agricultural operations. But, as these two requisites increased, the price of land and also that of labour were likewise increased; and, consequently, the profits arising from both were augmented.

Thus, in well cultivated and thickly populated countries, there will always be found to exist a proportion or equilibrium between the prices of land, of labour, and of produce, which in ordinary years is seldom found to vary, and which, if deranged by any accidental circumstances, is very speedily re-established.

This proportion is not, however, the same in all places: it is regulated by the relation between the quantity and quality of the soil, and the powers which can be brought to bear upon it; or by the degree of science and skill employed, or the capital which is invested in the cultivation. Where labourers are scarce, and skill and capital at a low ebb, the value of land is diminished, while that of labour is proportionally increased. But, in a populous state, on the contrary, where labour is easily procured, science pretty far advanced, and where capital necessary for the prosecution of agricultural operations is large, the value of land is proportionally greater.

This proportion between the price of labour and that of land contributes greatly to form the various systems of agriculture, which, in their extremes, may be called *great* or *small cultivation (grandes ou petite culture)*.* In those places where land is cheap and labour dear, it is always best to endeavour to obtain a certain quantity of produce from a considerable extent of surface, and with the least possible labour; but where, on the contrary, the land is very dear, and there are plenty of labourers to be obtained at a reasonable price, we must endeavour, by means of the greatest possible labour and care, to obtain an equal amount of produce from a small extent of surface, which is generally possible.

There are countries in America where an acre of land may be purchased at the price of a day's work. In Belgium, England, and some provinces of Italy, the same quantity of land can scarcely be rented at the price of eighty days' work per annum.

Whoever wishes to practise agriculture, and has a certain capital, may, in the former case, purchase an extensive piece of land, although he may choose to cultivate only a portion of it; but he must adopt the great or general system of agriculture, which will employ as few labourers as possible. But in the latter case, he must content himself with a small farm, not only on account of the dearness of the land, but also because he ought to reserve a larger portion of his capital in order to meet the expenses of the additional labour which will then be necessary. Where the land is cheap, it is sometimes possible to purchase large estates, the statute labour due to which is alone sufficient for all the indispensable operations; and where, if a person has sufficient stock, a very small sum of money will suffice for the expenses of cultivation.

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* I must entreat my readers not to confound the expression small (*petite*) cultivation with that of bad (*mauvaise*) culture. The former signifies a detailed system of cultivation which generally increases the produce; and the latter negligence, or an unskilful method of proceeding. Neither is great (*grandes*) culture synonymous with good culture, but only with cultivation managed on an extensive scale, executed chiefly by means of teams, in which, from the extent of the whole, the farmer is frequently compelled to neglect the details from want of the means requisite to enable him to approach nearer to perfection by taking care of both the one and the other.—FRENCH TRANS.

The lower the price of land, the less advisable is it to attempt improvements. Where an acre of land costs only fifteen rix-dollars, and the net produce of which is two dollars, it would, perhaps, be disadvantageous to spend fifteen rix-dollars on improving the soil, as by marl, for example, even if the produce would thus be doubled; because another acre of land might be purchased for that sum, from which the same amount of profit would be derived as would be produced by the improvements.

I say that it would, perhaps, be disadvantageous, because there are circumstances and cases in which it would be highly advantageous to devote that sum to the amendment of one acre of land, which would be sufficient to purchase a second.

For some time past agriculturists generally have complained of the excessive advance in the wages of servants and day labourers, and have regarded it as a crying evil. Many persons have attributed the high price of corn to that circumstance. In those countries in which statute labour has been suppressed, they have considered that alteration as the cause of the high rate of wages. But it is far more likely that it is the dearness of provisions, and the desire which is consequently felt to increase the amount of produce, which has raised the price of manual labour in proportion with that of money. The abolition of statute labour has rather tended to increase the industry of the labourer, and, consequently, the amount of work done has been much greater; and it ought to have the effect of lowering rather than of raising the price of labour.

But this complaint is often totally unfounded, and the advance in the price of labour is only imaginary. The value of money, with relation to other things, has diminished; while the price of provisions, and especially of corn, is much more advantageous than it used to be with regard to labour.

We will now proceed to point out those causes which are most influential in elevating or decreasing the price of labour, as calculated in money. They are as follows:—

1. *The price of provisions.* It is, of course, necessary that the labourers should earn enough to maintain themselves, their wives, and one or two children, and their support must be of a nature calculated to maintain their health and strength, and that of their children. If they previously possessed nothing beyond these absolute necessaries, and if provisions became dearer without the price of labour being also advanced, they would soon become so much enervated and impoverished as to be almost incapable of work; they could no longer maintain their children, or rear them up strong and healthy; and thus the quantity of labourers would, in a short time, be so much diminished, that the small number which did remain, capable of work, would be able to exact enormous wages. This fact, alone, tends to prove the absolute necessity of the existence of a certain proportion between the price of provisions and that of labour; and this proportion can never be interrupted for any considerable time, or without great disadvantage; and it speedily recovers its own level.

If the price of labour should, from some particular cause, advance beyond its due proportion with that of produce in some districts, and the labourers are thus enabled to earn more than is required for the actual necessities of life, they marry much sooner, rear more children, and, the number of labourers becoming greater, wages fall again.

It is true that this result does not immediately take place; it is not regulated by all the variations in the price of corn, but simply by an average taken from a certain number of years. The effect of a sudden decrease in the price of provisions will be much sooner evident, because then the labourers, who have hitherto only known want, and who have not the slightest idea of frugality, will be able to earn sufficient for their maintenance in three days, whereas they previously had to work five days for it. In this case they are easily induced to work two days less in a week, and thus the amount of labour is considerably diminished, and those who have absolute need of it are obliged to pay for it pretty dearly. But this state of things has also its limits, because, wherever this is the case, a great number of individuals will collect, and in the long run an increase of grain will only be found to stimulate a desire for still more.

In general, in all well-populated countries, the price of labour is regulated by that of provisions; and in the ordinary course of things, in most places and at most seasons, the same quantity of manual labour will be received for a measure of wheat, although the nominal price, that in money, may not be the same.*

In order to maintain a certain uniform standard of wages, an agriculturist who has established the necessary number of labouring families upon his estate, will act most beneficially to his own interests, and equitably towards them, by giving them a portion of their wages in provisions at a certain price; or, if he is certain of their work at all times, by increasing or augmenting their wages in proportion to the price at which these families can purchase these provisions.

In order to maintain himself, support his strength, and, at the same time, rear two children, a labourer ought to be able to earn a bushel of rye in eight days, without too great exertion or extra work: the wife is supposed to be capable of earning her own living. From time to time, and particularly when provisions are dear and the labourers have earned less, they have been indemnified by other advantages which rendered their existence possible, and which certainly ought to be taken into account when speaking of the price of labour.

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* The province of Vignolles is an exception to this rule: there each labourer receives a ration of wine every day; and as this draught but slightly diminishes the quantity of food, properly speaking, which he consumes, the price of his day's work is raised seven-eighths of the value of the wine; in fact, it is more than probable that this drink increases his strength.—FRENCH TRANS.

I shall take one-eighth of a bushel of rye as the average daily wages of a man. And as the relative prices of labour and of grain give, in agricultural accounts, a much more durable proportion, and is much better adapted to all times and all situations, than the variable value of money, I shall take this price of a day's work, or eighth part of a bushel of rye, as the ideal coin of our agricultural accounts, and shall designate it by this mark. ‡ *

If we wish to reduce this imaginary money to the current coin, it is only necessary to obtain the average price of a bushel of rye for ten years in the province or district which we inhabit. Thus, for example:—

If the bushel of rye is worth—

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | 1 rix-dollar, | a groschen | ‡ will be equivalent to | 3 gros | 0 | den. |
| ,, | 1 .. | 3 .. | ‡ .... | 3 .. | 4½ | ,, |
| ,, | 1 .. | 1 .. | ‡ .... | 4 .. | 6 | ,, |
| ,, | 2 .. | 0 .. | ‡ .... | 6 .. | 0 | ,, |

As the price of labour and the consumption form the most considerable part of the expenses of agriculture, the abstract and hypothetical calculations which we shall have occasion to make with regard to the details of rural economy, will thus be rendered generally more admissible and more correct than if we were guided by money, which always indicates the mere nominal price of things, and not their actual value.

2. *The increase or diminution of the demand for labourers.* When the demand for labourers is increased, the latter naturally endeavour to get their wages raised,

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* In those countries in which the peasantry are accustomed to enjoy more of the comforts of life, and where wheat forms a considerable part of their food, the eighth part of a bushel of that grain will be the equivalent of a day's work (*French Translator*).—One peck of wheat has been long reckoned a standard in England (*English Translator*).

and thus the price of labour is advanced throughout the whole country. An increase in the price of labour from this cause, so far from being prejudicial to the agriculturist, is, on the contrary, most advantageous to him. It is, at once, the effect and the cause of a diffusion of comfort and ease throughout the country: in the case of the agriculturist, it is, perhaps, connected with still greater advances; but it is certainly and invariably with additional advantages; for comfort, which is the fruit of industry, necessarily causes an increase of consumption, and with that a higher price of provisions. There is, however, an exception to this rule, viz., when the increased demand for labourers does not arise from any certain branch of industry, or of any permanent employment, but merely from some speculation or some temporary work, as the establishment of a new road, the cutting of canals, &c.; it is then that the sudden elevation of the price of labour becomes prejudicial, and is frequently very embarrassing to the farmer. If governments would avoid the derangement of the agriculture of their country, they must never, in cases of this nature, levy all their labourers in the country itself.

If, on the contrary, industry has declined in some particular province, and labour is less sought for, then the labouring class of that place cannot obtain employment, and their salaries are, consequently, diminished. A diminution of the price of labour always announces the decline of industry; it is the forerunner of its total fall and of poverty, and, consequently, never can be advantageous to the agriculturist.

Nevertheless, as a demand for labourers in any particular district and an advance in their wages speedily brings a great number of them to that place, while, on the other hand, any great decrease of these two articles will drive them away or reduce them to poverty, it will generally be found that wherever labourers are required and well paid, they will congregate.

This price is, therefore, only temporarily modified during an increase or a decline of industry. If the price of labour has remained the same for some time, it is because there has been exactly the number of labourers that were required; for this price, particularly if we regard the real and not the nominal price of labour, and its proportion with the value of produce, is not usually higher in countries where the working classes find full employment, nor lower in those where the contrary is the case. Proper remuneration will always procure the necessary number of labourers in any country, whereas the want of it will cause them either to emigrate or to starve from want. Where the latter has happened, the farmer has frequently sought in vain for assistance in moments of emergency, and in seasons when he required it most; and as the labourers cannot get employment excepting at harvest or haymaking seasons, they take care then to make the farmers pay dearly for their services.

This is the reason that the price of agricultural labour is much lower in proportion to other things in England than it is with us; and that in some counties it is so inconsiderable, that the labouring classes could scarcely exist if they were not kept in constant work, and did not receive assistance from those charitable institutions which, on other accounts, are so burdensome.

In examining and calculating the price of work, we must be careful not to confound the price of the wages with that of the work itself. There are some countries in which the former is much higher than it is in others, while the latter is actually lower; for men differ greatly in the degree of their strength, activity, and skill, and much depends on their poverty or the comforts which they enjoy. A workman to whom I pay twelve groschen a day, can frequently execute more than double the work, both in quantity and quality, as another to whom I only pay six groschen. Consequently, where the labourers are industrious, and skilled in some portions of agricultural operations, it is cheaper to employ them, even though they may require somewhat higher wages.

Labour well applied is always productive of some profit, and those who spare it act on a false principle of economy; but the best and most judicious method of employing labour and time is the most important of all subjects to the real economist. Many persons learn this method from long experience; and it is true that the tact and *coup d'œil* thus acquired is peculiarly just. But it may be acquired much more promptly and definitely by the observation of certain principles, from which a theory of action may be deduced, without serving a tedious and expensive apprenticeship to experience.

It is far more difficult to apply labour judiciously to agriculture, than to apply it to the manufacture of fabrics; for the labour which is required for some particular kind of produce, lasts but a very short time, and is then suspended for a much longer period, during which the farmer depends upon the action of nature to bring this production to perfection, and awaits the proper season for gathering it. After each species of grain has been sown, it requires very little or no attention for some time; whereas, in the formation of any kind of fabric, the labour must be continued from the very commencement until the completion. In order, therefore, that the farmer may make the very best possible use of the powers which he has at his command, he should endeavour to arrange the succession of his crops in such a manner that every hour shall be devoted to some preparatory and necessary operation. It is also necessary that he should select the products so as never to have more necessary operations in hand at once than he can accomplish by means of the powers which he has at his disposal, or which are within his reach.

He must never undertake many extensive operations at once, or in places remote from each other. He should endeavour, as much as possible, to perform them one after another, and to employ upon them all the men he keeps, from the beginning to the end: this will render the task of inspection easier, and may also tend to excite that emulation which frequently arises when many labourers work together under the same superintendence. When only a few workmen are employed on some extensive operation, they frequently become dismayed at its length, and at the little progress they appear to make; they lose all spirit, and end by believing that it is impossible to discover whether or not they work at all. In great operations it is always better to have a man or a team too many, than to have one less than is necessary. In smaller operations, on the contrary, it is as well to avoid employing more labourers than are absolutely necessary; they only hinder one another, and are apt to think that the farmer believed that the work would take more time than actually is required for the accomplishment.

A judicious estimate of the labour requisite for every operation is, therefore, of the greatest importance; and it will easily be acquired by carefully observing the time and labour applied to each separate portion and to the whole.

There are some operations which require a certain degree of temperature: the farmer must always hold himself in readiness to set about those as soon as the fitting time arrives, and must get them done as soon as possible. Should he be interrupted by change of weather, it will be contrary to the rules laid down in the preceding section to pass to any other extensive operation, unless some particular motive, or an appearance of this change of temperature being of long duration, should seem to indicate such a course. In such intervals it is much better to set about some of the smaller operations, which are, in point of fact, of equally as much consequence, and can be very soon completed. It ought to be held as a rule, that no operation once taken in hand should be laid aside, except in case of absolute necessity; and the farmer ought always to hold himself in readiness to resume that which was first undertaken as soon as the weather will admit.

In reaping or stacking corn, planting or digging potatoes, &c., on extensive farms, the division of labour may be so managed that one part of the labourers shall work with the teams while the others perform the manual labour; or that certain operations shall be committed to the care of certain men in each season. But the variety of these works seldom allows of the same individual being employed all the year round on one thing.

There are many operations which can be performed by women and children as well as by the strongest men, and the former cost much less. It is very important to distinguish those operations which ought to be executed by men from those which may be accomplished by women or children, in order that each of these classes may be employed throughout the year on the work best adapted to their powers and strength.

### *On Draught Labour—Horses and Oxen.*

As the number of labourers which it is necessary to employ depends greatly upon the teams which are kept, we shall commence by treating of these latter. Teams are, for the most part, composed either of horses or oxen. It is seldom that asses or mules are used.* There certainly are some countries in which the small farmers are in the habit of harnessing the cows,† and where such a proceeding does not seem out of place: I see no objection to these animals being taken into work in cases of need, but their general use does not appear perfectly right.

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* The mule is peculiarly adapted to every species of agricultural labour. He lives much longer than the horse, he is much more abstemious, stronger, and capable of supporting the greatest fatigue. His only faults are, that he costs more; that his foot is straighter and narrower, and, consequently, sinks deeper into ploughed land, and that he is apt to become vicious when ill-treated by the persons who have the care of him. Notwithstanding these inconveniences, the mule will always be found exceedingly useful in agricultural labour.—FRENCH TRANS.

† Cows do not seem to be at all injured in health from being harnessed to the plough or waggon. When they are only worked half of each day, the value of their milk is not diminished more than + 0·13, and about twice as much if they are worked all day; but it becomes as abundant as before as soon as the animal is no longer required to labour.

No cow should ever be placed in the shafts, particularly in heavy work, which requires the simultaneous co-operation of more than one couple of draught cattle, or, indeed, in any work which requires extraordinary labour; because, although the cow may have sufficient strength to bear it, her efforts are very likely to produce abortion. Cows may always be used before oxen, provided that too great an exertion of strength is not exacted from them.

With a little exertion of patience and gentleness, a cow may usually be habituated to labour in a very short time; this will invariably be the case where the animal is broken in while young, and where they commence by making her draw light weights.

It has been a matter of dispute for some time whether the preference should be given to oxen or horses as beasts of draught, and both sides have contested the point with

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The pace of a cow is generally rather quicker than that of an ox; and when of the same breed, its strength and powers of endurance average about two-thirds of that of an ox.

Cows which are worked always require rather more food than those which remain in a state of inaction.

According to the following proportion, the usual day's work of an ox is worth + 1·6; that of a cow, + 1·06.

The latter costs the owner:—

| | |
|---|---|
| The additional quantity of food given during two days, supposing that the cow is only worked for half a day, each day 6 to 5 of the 100 kilogrammes | + 0·3 |
| The loss in the milk | + 0·26 |
| Accidents and misfortunes | + 0·1 |
| | 0.66 |
| There is some deficiency in the quantity of dung; but in general that which is missed from the stable has fallen on some part of the fields, where it is not entirely lost, and the additional nourishment compensates for the deficiency in the stable. | |
| There is, consequently, a net profit on each day that a cow is worked, of | + 0·40 |

Or, to explain myself more clearly, the amount of work executed by a pair of oxen in one day will cost + 3·2, while that executed by two cows will only cost + 2.

And if, as will be seen by the note attached to p. 73, *post*, the expense of work executed by oxen is, when compared with that executed by horses, as + 4·32 is to + 3·1, so the quantity of work executed by a pair of horses in one day, and costing + 3·1, would, if performed by cows, only cost + 2·72.

Besides, the pace at which cows move being much quicker than that of oxen, if proper attention be paid to the manner of harnessing or yoking them, and to the equalizing of their strength by numbers, so that they may be able to overcome the same resistance as the latter, their conductor will find his time quite as usefully employed as if he were with horses, and much more so than if he drove a team of oxen.

But the benefits of which I have already spoken are not the only ones which are derived from the practice of harnessing cows; however judicious may have been the distribution of crops, it is almost impossible to avoid having an accumulation of team labour all necessary to be done at one particular period. By keeping the number of horses and oxen necessary to secure the execution of all these operations at the most advantageous and fitting time, the farmer will be burdened with a quantity of beasts which, during the greater part of the year, he will have no use for; and, consequently, each day's work will cost an enormous sum. But by early accustoming his cows to labour, he will, on the contrary, always have a sufficient quantity of teams at his disposal, which are at no time in the year entirely valueless.—FRENCH TRANS.—[This note of the French translator is inserted to show the opinions of a Frenchman on this subject.]

too much prejudice, and sometimes with too much animosity; this is one reason why the question has never yet been decided, and why no positive results have yet been arrived at on the subject.

The preference must certainly be given, in most situations, to horses, on the following considerations:*

They are capable of all kinds of agricultural labour: they adapt themselves to every road and to every degree of temperature. Where horses are kept, there is no occasion to select the particular kind of labour to which they may be applied—they may be employed in any work, and be attached to every description of plough.

They perform all kinds of work very expeditiously, and are capable of sustaining their speed for a considerable length of time; consequently, the conductors are kept in fuller employment while working with horses, than when working with oxen.

Although less steady at heavy draught than oxen, the rapidity of their motion and their spirit enable them to overcome all obstacles of short duration which would frequently stop a team of oxen.

Oxen, on the contrary, have the following advantages in their favour:

They can execute most of the agricultural operations, ploughing, draught, &c., equally as well as the horse, and, when well fed, are capable of enduring almost as much fatigue. Many persons consider that they are more useful in ploughing even than horses.

Their keep is much less expensive. The original price of an ox is generally far below that of a horse; their harness also is much less costly; their food is much cheaper, and is of that nature which finds a much easier sale than the corn which is given to horses.

Oxen, so far from diminishing in value when they are well fed and not overworked, frequently become more valuable, and, on being sold, often fetch more than their original price, thus almost paying the interest on their capital; whereas, the horses decline in value as they grow older, until they are worth little more than their skins, and the capital expended on them is thus completely absorbed.

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* The Royal Agricultural Society of England has deemed this question worthy of investigation.

Oxen are also less liable to accidents and disease.

Lastly, they produce a greater quantity of dung, and the manure derived from them is generally more useful than that which is obtained from horses.

We shall be able clearly to demonstrate that which must already be apparent, that even those portions of agricultural labour which can be properly executed by means of oxen will not be executed so cheaply by them as by horses. If all the operations on a farm were of such a nature as to be easily performed by oxen, these animals only ought to be made use of. Although the operation of harrowing is far better executed by means of horses than by oxen, yet this does not, in my opinion, form a sufficient consideration to induce the adoption of the former. But in most farms there are many operations which oxen are still less calculated for, or, at least, which they perform very slowly. This would be a sufficient motive to induce a determination to keep a certain number of horses, regulated, of course, by the amount and extent of these operations, and to limit the number of oxen accordingly.

It is seldom possible accurately to calculate the number of horses which will be requisite for those operations which cannot be performed at any season, and thus horses are frequently employed on operations which could be executed at a much cheaper rate by oxen. Nevertheless, it is of the greatest importance to determine, as far as possible, the proper proportions of each of those animals; but that proportion varies on different farms, and must be calculated according to the extent and management of each separately; consequently, only general rules can be laid down for the regulation of it. There are, doubtless, some farms which, from their vicinity to the market town or some particular circumstances, ought to make use of horses only; because they contain so few operations which can be executed by oxen, that it will not be worth while to incur the expense of these animals, of a herdsman, &c.

In many countries the chief objection to the use of oxen seems to be the difficulty and almost impossibility of finding labourers who will work well with them.

When the farmer wishes to make his oxen get through as much work as horses, and without employing more men, he must manage so as to have relays of teams; that is to say, one ox shall work only a part of the day, and shall then be relieved by another. This change may take place twice or thrice in the day. It is seldom, excepting when the oxen are very low in condition, that it will be necessary to make use of a triple number of beasts. In general, when they are changed three times in the day, the ox which was used first in the morning and then relieved by another, may be re-harnessed in the afternoon: in this case he is only worked once on the following day.

A relay team of four oxen, employed on those operations for which these animals are best calculated, will do rather more work than two horses, if sufficient patience and perseverance is manifested by the conductor, who must not quit the spot during the whole time the labour lasts, and to whom the relays of oxen must be brought by the herdsman or cow-boy. It is, however, true, that the same number of beasts when they are not worked alternately, and only rest for a short time at noon, can get through more work than if they were used as relays; but then they must be better fed, and will, if worked all day for many successive days, become over-fatigued; but two oxen worked permanently will never be found to get through as much work as four worked in relays can do, and, consequently, their conductor is not so fully employed. The proportion between oxen worked as relays and those which are permanently employed, is about three to four. This difference is, however, in part compensated by the increased labour of the man who conducts the team. But it must be confessed, that for every six oxen a supernumerary one ought to be kept. In those places where the farmers have learned to appreciate the advantages of relay teams, they do not appear at all disposed to discontinue them. Nevertheless, during the short days of winter, when it is only possible to work for a few hours each day, the relays may be separated, and allowed to work during the whole time.

It is a very common, but a very unfounded, prejudice to suppose that oxen must not be worked in the winter; or that they must be kept in idleness, and that it is not necessary to feed them well. In a well arranged system of agriculture, there is always work sufficient for the oxen in the winter, if the roads are passable.

The ox is not more sensible of the cold than the horse; on the contrary, if he is well kept during the winter, he is very lively and active. The danger of slipping down on the ice or frozen roads may be averted by putting on a light shoe. Those oxen which are well fed and moderately worked, are much more active and tractable than those which have been shut up all the winter in idleness.

Where oxen are used, more days are lost during wet weather, or when the roads are bad, than where horses are employed. If each horse may be reckoned to work three hundred days in the year, supposing, however, that for every twelve horses one is kept in reserve to supply the place of those which are sick, the number of days' work which must be reckoned for an ox is two hundred and fifty.

According to these data, and to the calculations which we are about to transcribe relative to the expense of keeping horses and oxen, it will be easy to decide in each particular case, whether horses or oxen will prove most advantageous, and whether both or only one of these kinds of animals should be kept.*

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* The question of whether the preference should be given to horses or oxen has been left, to a certain extent, undecided; and, indeed, in order to resolve it in such a manner as to remove all doubts on the subject, we must be possessed of a great number of experiments and observations which would require considerable sacrifices, and, moreover, be exceedingly difficult to collect.

It is probable that the size and breed of the animal, the climate and nature of the soil, may affect the relative utility of the two kinds, so much as to exert considerable influence on the expediency of employing them, and to render

With regard to cart and plough horses, we must observe, that, in purchasing them, many farmers pay attention only to the lowness of their price, and never concern themselves at all about the time when the horses

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the one which is well adapted for one country to be exceedingly disadvantageous in another. We shall, however, endeavour to examine the subject with somewhat greater arithmetical accuracy than has hitherto been applied to it.

From experiments which I have myself made, and which, from their accuracy, are entitled to some degree of confidence, I am convinced that with beasts of draught, as well as with the human race, there are considerable differences between the quantity of food required by different individuals of the same species, and still greater differences in the quantity of food which they will actually consume if suffered to eat as much as they like. Thus, of a pair of horses of the same age and breed, one will often consume 22 kilogrammes of hay per diem, while the other will eat only 15 kilogrammes, or even less. I am also convinced that with the exception of a few individuals possessed with more sense, or more devoted to the interest of their master than is generally the case, it is the constant practice of servants to give the cattle a greater quantity of food than they actually require.

Hence result the endless variations observable in the quantity of food consumed by cattle. According to my experience, a good draught horse of the usual size will eat from 16 to 22 kilogrammes of artificial hay, clover, sainfoin, or lucerne, besides corn. Thus averaging about 19 kilogrammes a day.

If the horses are fed with natural hay, they consume about an eighth less; but, however excellent in quality this kind of food may be, the horses lose condition rapidly if corn be not also given to them.

This difference between natural and artificial hay is modified by the locality, the nature of the soil on which the grass is grown, the manner in which it is watered, and, lastly, by the plants of which it is composed.

An ox of the Swiss breed, of stature sufficient to make him equal in strength and vigour to a horse, without, however, being unwieldy, will consume from 17 to 23 kilogrammes of artificial hay per day, or 20 kilogrammes on an average. (A kilogram is equal to 2 lbs. 3 oz. 5 dr. avoirdupois.)

| | | |
|---|---|---|
| The harness of a horse usually costs about 72 fr., the interest of which at 5 per cent., amounts to | 3fr. | 6 |
| The annual wear and tear, including repairs, may be estimated at | 12 | 0 |
| The shoeing | 14 | 0 |
| Lighting the stable | 4 | 0 |
| Interest on capital (suppose it to be 480fr.) | 24 | 0 |
| Decay, and chances of mortality | 48 | 0 |
| Cleaning and attendance in those days during which the horse does not work | 5 | 0 |
| | 110fr. | 6 |

I shall not here take into account the rent of the stables and hay-lofts, or the cost of the litter and of medicines; neither shall I make any deduction for the value of the dung. I suppose these items to compensate each other in the keep of both horses and oxen. In my establishment the oxen are far more frequently ill than the horses; and this is attributable to the following causes: —1st. They have suffered frequently from flatulency, through the ignorance of servants, who have fed them too plentifully on moist and very young clover. 2nd. In very hot weather they have been often attacked with inflammatory diseases. 3rd. Notwithstanding every possible care to prevent it, they have been wounded several times near the base of the horn in putting on the yoke. 4th. They have often bruised their feet while drawing carts and waggons in will no longer be serviceable. They always decrease in value, these persons will say, as they advance in age; and the higher the price we gave for them, the greater in proportion is our loss. By the purchase and sale of indifferent

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dry weather, or over stony roads; and the same accident has sometimes happened when they have travelled some considerable distance over wet and heavy roads. This evil may, however, be averted by a light shoe.

| | | |
|---|---|---|
| The harness of an ox, comprising the half of the yoke for the head and neck, and the traces, usually costs about 12fr., the interest of which at 5 per cent. amounts to | 0fr. | 6 |
| The annual wear and tear of this harness | 3 | 0 |
| The shoeing | 3 | 0 |
| Lighting the stable | 1 | 0 |
| Interest of the capital (suppose it to be 288fr.) | 14 | 4 |
| Chances of mortality | 7 | 2 |
| Attendance during those days in which the horse does not work | 2 | 5 |
| | 31fr. | 7 |

An ox, when no longer used for work, may usually be sold at the price originally given for him, and will even fetch more than his original price if he has been put up to fatten; but this latter circumstance supposes that he has been kept in idleness for a considerable time, and has been particularly well fed and carefully tended, and is, therefore, altogether foreign to the present calculation. We will, therefore, suppose that the ox is sold at the same time of the year at which he was purchased, and in such a case he will fetch about the same sum. We will now sum up these data.

| | | |
|---|---|---|
| The keep of a good draught horse for 365 days, at 19 kilogrammes of artificial fodder per day, or its equivalent in clover, lucerne, green tares, or in boiled potatoes, or carrots, amounts to 6,935 kilogrammes, the value of which, at 5fr. for every 100 kilogrammes, is | 346fr. | 75 |
| An additional supply of corn during two months of extra labour, before the horse is turned out to grass | 8 | 0 |
| Expenses already estimated | 110 | 60 |
| | 465fr. | 35 |

According to my own experience, I should say that a horse cannot be worked more than 260 days with advantage. The author, whose experience is of much longer standing than mine, gives it as his opinion that a horse may generally be worked 300 days in the year. If we divide the sum total by 300, we shall find that the daily expense averages about 1fr. 55c.

| | | |
|---|---|---|
| The feed of an ox amounts to about 20 kilogrammes of artificial fodder, or its equivalent in clover, lucerne, green tares, boiled potatoes, or carrots; total, 7,300 kilogrammes per year, the value of which, at 5fr. per 100 kilogrammes, amounts to | 365fr. | 0 |
| Expenses above detailed | 31 | 7 |
| | 396fr. | 7 |

I should also estimate, from my own experience, the number of days which an ox can be worked in the year with advantage is 220; but our author reckons it at 250. Now, a day's labour of an ox being in value to that of a horse as 3 to 4, these 250 would only be equivalent to 187·5 days' labour of a horse. Dividing 396fr. 7c. by this number, we obtain a daily average of 2fr. 11c. In this calculation I have not taken into account the greater amount of time expended by the drivers of oxen in the execution of those operations which are performed so much more expeditiously by horses. Hence it follows that the same quanhorses, it is scarcely possible to lose to the same amount; and the necessity of employing a large capital is also obviated, and less damage sustained in case of accident. They therefore generally purchase horses which have been badly used, or are no longer suited to the work for which they were originally intended, but which are, nevertheless, still capable of drawing the plough or the harrow; and they base this practice on recollections of animals thus purchased, which have been brought into such condition by dint of care and good feeding as to be equal to all the work required from them, and which have afterwards been sold for more money than they originally cost. If the maintenance of the horse, under different points of view, were the only thing which it was necessary to consider, this mode of proceeding would not be so bad. But, in agricultural operations of any extent or continuance, horses of this description are not to be depended upon. They are subject to frequent attacks of illness, and the amount of work of which they are capable is very doubtful; besides, in cattle thus collected, all have not an equal proportion of strength, courage, or endurance; nor are

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tity of work which, when performed by horses, would cost only 3fr. 10c. would, when performed by oxen, cost 4fr. 22c. The calculations which are contained in some subsequent pages exhibit the numerous differences which exist in the manner of feeding animals in different countries and districts. That the prices of all commodities are equally variable is a fact of which very few can be ignorant. I have not pretended to decide so delicate a question as the expediency of keeping most horses or most oxen, or of confining oneself either to horses or oxen; but have merely endeavoured to put each of my readers in the way of making an estimation of their advantages or disadvantages for himself, according to the peculiar circumstances of his agricultural operations, and the price of each commodity in the country in which he lives.

There cannot be a doubt that, in places where the farmer has an abundance of pasture ground at his disposal which he cannot otherwise employ, the saving it will produce to him in food for cattle during the summer will greatly modify this estimate; but this modification will not actually be so great as it appears at first sight, because the ox which has had to seek its food in the fields is neither so strong nor so fresh as one that has been fed in the stable and had a good supply of rich fodder.

It appears, also, that in some countries the ox is more moderate in his appetite, and consumes less food than those in the country in which I live; on this point every one must endeavour, by repeated experiments, to ascertain the average of his particular locality, and make his calculations accordingly. I have supposed the oxen to be fastened together with yokes; I am, however, far from admitting that this is the best method; but I believe it to be that which is most generally practised.—French Trans.

they all equally accustomed to work; a regular and systematic course of tillage cannot be carried on with such teams, unless, indeed, several additional horses are kept in reserve. If we cannot depend upon the force which is at our disposal, all tables and calculations become utterly useless. It not unfrequently happens that a pair of horses, which are unable to work, and whose places cannot immediately be supplied at a time when several urgent operations are necessary to be done, will occasion a loss which will far outweigh the profit expected to result from the saving in question. The non-employment of the one causes irregularity in the work of several others. I am, therefore, of opinion that these worn-out horses can only be advantageously purchased for spare or relay teams, or to be temporarily employed in improvements, buildings, or repairs.

The principal teams should consist of horses of the same breed, well set about the shoulders and neck, having a deep chest, and round in the carcass. They should not be large boned, but have plenty of sinew; should be docile and patient, not too spirited, and have good legs and feet. It is only on very tenacious soils that it is necessary to use the large heavy horses, which require an abundant supply of food and very great care in order to keep up their strength. For ploughing, it is necessary to have robust horses, which are able to stand constant work, and keep up their flesh and strength even when badly tended and irregularly fed.

This breed of horses was formerly common to several provinces of Germany; but, at the present day, it is becoming scarce, because the growth of those belonging to small farmers has been retarded or impeded by want of attention, and by premature labour; and on the large estates the breed has been crossed and re-crossed, until it is deprived of all those qualities which rendered it so valuable for agricultural purposes.* Those among the large farmers who do not breed horses, and endeavour to improve and beautify the race to the utmost, expressly for the purpose of selling them to the highest bidder, have almost wholly abandoned the practice, from the persuasion that they can purchase all those which they require for their agricultural operations at a much cheaper rate than they could rear them on their own estates.

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* An evil which exists to an incalculable extent in this country. A colt or a calf is what is sought for, no matter what the character; the principal question is, at how small a price the services of the male can be procured.

But those who know the value of a strong, active, vigorous, and well-proportioned breed of horses, will consider the advantage of possessing such animals as are fully equivalent to the extra expense of rearing them. A team of horses, bred upon the land, and matched not so much with regard to colour as to bodily strength and endurance, may be used with a degree of confidence which can never be felt when using cattle differing from each other in qualities and in breed, or which were purchased at different places. Low-priced horses, and especially those which have already been in the hands of horse-dealers, have generally been forced in their growth, and subsequently brought into condition by rich and plentiful feeding; and have thus laid the foundation of a variety of diseases. This internal weakness in horses is the cause of frequent accidents, and it is often difficult to discover whether they are attributable chiefly to want of attention or to weakness of constitution. When horses of different breeds are harnessed together in the same team, and it is difficult to avoid this where the horses are separately purchased, they harass and impede each other; the quick ones incommode those whose movements are slower, and these latter are a hinderance and a drag upon the quicker.*

Moreover, in the generality of agricultural establishments, as we shall elsewhere prove, the rearing of horses is neither so difficult nor so expensive a matter as is generally imagined.

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* The author very judiciously recommends the having a select breed of horses on every farm, suitable to it, and, when once obtained, to breed from that stock, in preference to buying animals from totally unknown sources, provided circumstances will permit. By breeding horses, better opportunities are afforded of procuring constitution, strength, and action in the animal, and the necessary equality in these particulars; and also a proper training, by which many vicious habits are prevented.

When the mares are put to the male at the proper season, little of their work is lost. The time at which they bear a foal and begin to suckle occurs at a season of the year when they may be allowed to rest, and from that time they require no further attendance.

In external apperance a good ox should be distinguished, not so much by height and length as by a square built form, his neck should be finely shaped towards the head, and thicker towards the shoulder and breast; the chest should be deep and broad, the flanks full, the loins wide, and the hips large. The back should be straight and broad, and nearly level from the head to the rump. The legs straight and sinewy, and the hoofs long and hollow; and both legs and feet should be supple, and not stiff and awkward. The ox ought not to knock his hind legs together, as is often the case with those which are narrow and high in the legs. He should have a brisk air, and a backward glance of the eye, without, however, being shy or intractable. Large and smooth horns are at once an indication of health and strength, and useful for fixing and supporting the yoke and the guides. The English consider a thick, clumsy head, and a large dewlap, as an indication of weakness or deficiency in other parts; while many persons, on the contrary, regard these as favourable signs. The height of the ox from the feet to the withers, to which many give exclusive attention, is a very uncertain indication.

Young oxen may be harnessed at the age of five years; but if the farmer wishes his cattle to acquire their full strength, and to retain it for any considerable period, he must avoid over-loading or over-working them before they have attained their seventh year.

It is the opinion of most agriculturists that an ox should not be suffered to live more than ten years, because, after that time, he becomes unfit for fattening, and it is difficult to dispose of him. Nevertheless, even supposing that an ox does lose somewhat of his disposition to fatten, and his flesh becomes less valuable—facts which I have never yet been able to discover, since I have often obtained excellent meat from oxen thirteen years old, which have fattened kindly—the work which strong and well-trained beasts of this description are capable of performing, will alone render it worth while to keep them longer. It is not until his ninth year that an ox acquires his full strength and vigour, and is best able to endure fatigue; and he will continue equally active until he is sixteen years old, if he has not been over-wrought in his youth.*

Few things require so much care, patience, and attention as the training of oxen, accustoming them by degrees to draught, gradually increasing their load, and teaching them to move more quickly by harnessing them with those which move rapidly. Their subsequent utility depends, in a great measure, upon this training; and it is, therefore, most important that the business should be entrusted to experienced persons, who will prevent them from acquiring a habit of creeping along, without the general cause arising from over-loading or over-heating them.

If, in rearing, tending, and training oxen, the same care and attention were used as are bestowed on horses, the improvement of the ox might be carried to a very great extent.

In the feeding of horses the following instructions must be attended to. The kind of grain generally given to them is oats, and many persons consider this as the only kind of grain which is good for them. It is, however, certain, that a proper quantity of any species of grain, each in proportion to its nutritive qualities, is both profitable and beneficial to horses.

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* The age of oxen here mentioned appears extraordinary, being so much greater than is known to attain in England. The early maturity to which our breeds have been forced, may, in some measure, account for it; but an ox capable of work at the age of sixteen years, seems to require a greater cause to occasion the difference. Ours are rarely worked beyond seven years old. There was, some years since, a wild ox at Chillingham Castle, in Northumberland, which had reached the age of seventeen years, having been kept for the purpose of trying the period of extreme longevity. The animal died at that age, having for some years previous been unable to move to any distance, or to feed on the usual articles of maintenance. The ages stated by the author appear incredible in our country.—EDITORS.

Vegetables, as beans, peas, and tares, are perfectly well adapted to the constitution of the horse, and are even preferable to grain properly so called. The kind of grain which can be given to horses with most advantage, is always that which can be obtained at the cheapest rate in proportion to its nutritive qualities. The proportional value of different kinds of grain, as will be shown more at length in another place, is as follows :—

| | |
|---|---|
| Oats | 5 |
| Barley | 7 |
| Rye | 9 |
| Wheat | 12 |
| Vegetables | 10 to 11 |

It is customary to give the horses a quantity of hay along with their corn, the nutritive qualities of which cannot be denied; and also chopped straw, which latter is given with the intention of facilitating mastication and filling the stomach, but which contributes little towards nutrition, properly so called, when there is no grass mixed with it.

In proportion as the quantity of hay is increased, the quantity of corn may be diminished, and *vice versa.* Experience tends to prove that an increase of corn is most advantageous for quick and forced work, but that an additional quantity of hay is best for slow and continuous labour.

A tolerable-sized horse, properly worked, generally requires about 10 lbs., or 3 *metzen* of good oats a day throughout the year, and as it is frequently necessary to increase this quantity, the yearly amount must be reckoned at 70 bushels.*

Besides this allowance of grain, it is also necessary, in order to keep up the strength during long and continuous labour, to give 10 lbs. of hay each day; and, lastly, a quantity of cut straw is mixed with the corn, and increased or diminished in proportion with the quantity of hay given to the horse.

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* The word here and elsewhere translated bushel is a German word (scheffel). It seems to be applied to a great many different measures. At Berlin, the *sheffel* is nearly twice as much as the English bushel; at Stutgard, between three and four times as large as at Berlin; at Weimar, between two and three, and at Munich, four times as large. The *metzen,* also a German measure, seems to be of such a size that 14 two-fifths are required to make a bushel.

The annual feed of a horse therefore costs—

| | | |
|---|---|---|
| 70 bushels of oats at 5 ‡ | 350 | |
| 33 quintals of hay at 3 ‡ | 99 | |
| | | 449 |
| To which must be added | | |
| Interest of purchase money | 24 | |
| Annual decay | 48 | |
| Shoeing | 14 | |
| | | 86 |
| Total | | 535 ‡ |

The straw is omitted, as being compensated by the value of the dung.

If a bushel of rye be valued at 1½ rix-dollars, one ‡* will be worth four groschen six deniers, and consequently a horse will cost one hundred rix-dollars and seven groschen per annum.

It is very difficult to estimate the yearly expense of the keep of a horse in those places where they are grazed all the summer, or where they are fed during winter on chaff only, or during harvest time on the cuttings of the sheaves and a little corn; these customs are altogether incompatible with an active system of cultivation, and are not at all calculated for those teams which are in constant work.

There is now no longer any doubt that horses may be kept in perfect health and vigour without having any corn, and by means of a far less expensive system to the farmer, viz., that of giving them clover and green tares in summer, and potatoes, carrots, and other nourishing roots, in the winter. Although the quantity of these roots consumed by the cattle is so great as, when the value of them is reckoned according to the market price in towns, to render the advantage derived from the use of them apparently doubtful, yet, since they are less expensive to the grower than corn, and the carrying of them to market would be attended by very great inconvenience

* See p. 62

and expense, it is better to have them consumed by the cattle during the progress of the agricultural operations. The results of several experiments performed on a large scale have rendered the advantage of this system of feeding no longer doubtful, and when it has become generally understood and adopted, the question as to the respective merits of horses and oxen will, perhaps, be differently considered. We shall enlarge more fully on this subject elsewhere.

In order to keep oxen in good condition, they should receive, on an average, 20 lbs. of hay each per day during the whole of the time that they are kept upon dry food; consequently, 40 quintals of hay must be allowed for each ox. If a considerable quantity of chaff or winnowed siftings be given, 30 quintals will be sufficient. By this means their strength and health will be fully sustained, and they will be equal to all the labour which may be required of them during the winter.

In those establishments where so great a quantity of hay cannot be spared for the oxen, its place is supplied by the grain which is best adapted for this purpose, after having passed under the mill-stone (crushed). A bushel of oats* in the feeding of cattle is equivalent to a quintal of good hay. If, therefore, an ox receives 3 lbs. of oats per day, his daily allowance of hay may be diminished by 6 lbs., and his strength will not decrease in consequence, and may possibly augment.

The best food for oxen during the winter season certainly is potatoes and other nourishing vegetables. If an ox receives two metzen† of potatoes, together with 12 lbs. of hay per day, numerous experiments tend to prove that he will be kept in full vigour.

In summer, when the oxen are turned into the pasture-field, one and a-half cows are usually reckoned to each ox; consequently, if the cost of a cow be estimated at four bushels of rye, or 36 ‡, that of an ox at pasture must be estimated at 54 ‡; or they are fed in the stable on green clover, tares, or other esculent vegetables. An ox, when rather severely worked, will consume one and a-half square perches of red clover on an average per day, in two feeds, and, consequently, an acre and a quarter in about four months. If an acre of clover be valued at 36 ‡, this will amount to 45 ‡.

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* About 26 kilogrammes.

† About 6 kilogrammes, besides straw *ad libitum*.—French Trans.

Thus, the maintenance of an ox, according to the different methods of which we have spoken, may be estimated as follows:—

| | | |
|---|---|---|
| (*a*) | 40 quintals of hay, at 3 ‡ | 120 |
| | Pasturage in summer | 54 |
| | | 174 ‡ |
| (*b*) | Hay for 200 days, at 18lbs. per day, 3,600lbs. at 3 ‡ per 110lbs | 98 |
| | Oats for 200 days, at 3lbs. per day, 12½ bushels at 5 ‡ per bushel | 62½ |
| | Pasturage | 54 |
| | | 214½ ‡ |
| (*c*) | Hay for 200 days, at 10lbs. per day, 2,000lbs | 54 |
| | Potatoes for 200 days, at 22lbs. per day, 44 bushels at 1 ‡ per bushel | 44 |
| | Pasturage | 54 |
| | | 152 ‡ |
| (*d*) | Stable feeding. | |
| | 18 quintals of hay at 3 ‡ per quintal | 54 |
| | 2 metzen of potatoes per day, 21 bushels at 1 ‡ per bushel | 21 |
| | Green clover | 45 |
| | | 120 ‡ |

In point of intrinsic value or nutritive quality, it may be admitted that 110 lbs. of hay are equivalent to 48lbs. or one bushel of oats, and to 200 lbs. or two bushels of potatoes. But the cost of reproduction, which the agriculturist should take as the basis of his calculation in all his own operations, is sometimes, as we have already observed, very different, and the market price is also subject to very great variation. Sometimes a bushel of oats will sell for more, and sometimes for less than

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110 lbs. of hay; and even when they are equal in value, it will be more advantageous to the farmer to give his beasts hay than to give them oats, because the former will yield a greater quantity of dung. It is the existence of this difference between the intrinsic value, the cost of reproduction, and the market price, which gives rise to the advantage of feeding cattle in one way rather than in another, and in part, also, to the advantage of keeping one species of cattle in preference to another, according as the kind of food the consumption of which is most profitable is best adapted to one or the other of these species.

Whichever of these systems of feeding may be adopted, the oxen, so far from losing condition or decreasing in strength, will, on the contrary, increase in value so much as even to cover the interest of their capital. If, however, in consideration of this interest and of casualties, 12 ‡ be added to the sum total, the keep of an ox in the best possible manner will even then scarcely amount to one-fourth of that of a horse; and even if we admit that four oxen working in relays will not do more work than two horses, it will still be done cheaper than if it were performed by these latter animals. It must, however, be observed, that in bad weather oxen working alternately are not available for so many days as horses, and that the proportion of the one to the other is 2 : 3, or at most 5 : 6.

In treating of the working of teams, we must also consider the implements by means of which the operations are performed. It is of greater importance than most persons seem to imagine, both as regards the execution of the work and the saving and the better employment of power, that the construction of the implement should be, as far as possible, perfect, and adapted to the locality, the soil, and the end which is to be attained by the use of it.

Although so much attention and study have been devoted to the improvement and perfecting of machines for the manufacture of fabrics, and so great and surprising a diminution of labour has resulted from it, yet little attention has hitherto been paid to the improvement of agricultural implements. This appears to arise, in a great measure, from the indolence of the farmers, from their want of mechanical skill, and perhaps, likewise, from the declamations of certain agricultural theorists. These persons have, in fact, inculcated the closest economy in the use of agricultural implements, and advised that they should not only be constructed at the least possible expense, but also that their number should be limited as much as bare necessity will allow.

They argue thus: the keeping in order of a plough of the least expensive kind, annually amounts to five bushels of rye, equal to 45 ‡. Now, if I can carry on my agricultural operations with ten ploughs of the same kind, and, nevertheless, ought to have ploughs of two or three different kinds, I must have at least a twentieth, and, instead of 50 bushels, these ploughs will cost me 100 bushels per annum, an expense which will scarcely be compensated by a saving in the employment of animal power. But even setting aside the better quality of the work, it will easily be perceived that this calculation is founded on erroneous principles. There certainly is less wear and tear in implements that are worked alternately, than in those which are in constant use; and if, when not wanted, they are carefully put away in a dry place, the wood, by being dried from time to time, will be kept in better preservation than if constantly used on a humid soil; this is so much the case, that it would even be advisable to have spare ploughs if only one kind were requisite. Nothing, then, but the interest of a larger capital can be charged to the account of this diversity of implements. Consequently, if an establishment which requires ten ploughs should absolutely spend 300 bushels of rye in procuring implements of a superior quality, or different construction, no annual increase of expenditure could thence arise beyond the interest of these 300 bushels; that is to say, fifteen bushels, and this would soon be compensated by the mere saving of animal power.

The enumeration, valuation, and description of agricultural implements must, however, be deferred to another chapter. At present we shall content ourselves with observing, in order accurately to determine the relative prices of these labours, that in general the expense of the whole gear in which, and with which, a horse works, may be estimated at the value of ten bushels of rye per annum. It will, of course, be understood that this estimate will be subject to modifications arising from locality, the price of blacksmith's work, the charges of the cartwright, the harness-maker, and of the rope-maker; and the nature of the soil and the condition of the roads. The cost of the gear of an ox, when employed only at the plough, has been estimated at no more than one-fifth of this sum. If they are also employed in carts and waggons, a kind of work for which they are not so well adapted as horses, but in which they cost less and do not require such expensive harness, the cost of two oxen working alternately must be estimated at scarcely half that of one horse. The harness-maker has little or nothing to do with the harness of oxen.

In order to obtain all the necessary data for a general valuation of the expenses of teams, we shall speak likewise of the men who work with them. It is principally necessary to know the exact power of the team to which the man is to be appointed.

If the expenses arising from the employment of carters were not taken into account, it would be most advantageous, according to the laws of mechanics and the results of certain decisive experiments, to employ beasts of draught singly as much as possible. For it is an acknowledged fact, that when the carriages are light in proportion, the animals can draw a much heavier load, and continue at work for a much longer period when harnessed separately. Four horses harnessed into two carts will draw a much greater load than when all are attached to a single vehicle. But they never draw so much as when each one is harnessed separately in a two-wheeled cart of suitable construction. Experiments made in

England have proved that four horses harnessed separately in four two-wheeled carts are equivalent in power to eight harnessed together in one waggon. This is accounted for by the deviation of the different lines of traction, the unequal application of power, the want of absolute conformity of motion, pace, and traction, and the frequent action of forces in opposition to each other, which takes place when the horses are united in one team. When a horse works alone he may keep the true line of traction, and preserve an uniform rate of motion; he is not urged on by emulation, or forced into exertions beyond his strength by the activity, or impeded by the sluggishness, of his companions. But the horses must be well trained and be accustomed to the guidance of signs and words, and the harness and vehicles must be carefully arranged, or it is utterly impossible that one man can regulate and guide three or four horses, when each one is attached to a separate cart. And since it is impossible always to employ an equal number of one-horse vehicles at a time, only one man is kept for the horses, who takes care of them in the stable, and those which work with them are hired by the day or by the task. This system also requires good and even roads.

If, according to our custom, the servants who look after the horses are also made to work with the teams, only one man is usually allowed for every four horses, and, in that case, when the work is heaviest the straw is cut ready for him. In some agricultural establishments two men are allowed to every four horses, the second being termed assistant carter or stable-boy. This arrangement is generally found on, and is particularly adapted to, those farms in which the horses are principally used for ploughing, and are harnessed in pairs instead of teams consisting of four animals.

Where four horses are worked together, it is customary at times, when it becomes absolutely necessary to separate them, to entrust two to a day labourer, or an assistant driver is kept for a number of teams.

The custom of using three horse teams, which has lately been introduced into some countries, or that of keeping one man for three horses, is in my opinion disadvantageous. If the expenses of the household, properly so called, be equally divided amongst the several persons which compose it, the keep of the man who looks after the horses must be regarded as equal to 34 bushels of rye. I estimate the wages and other perquisites of each servant at 16 bushels of this grain. According to this calculation, a man capable of driving and taking care of a team of four horses, will cost the value of 50 bushels of rye per annum.

With regard to oxen, it is generally managed that one man shall attend to and feed or look after them in summer while they are grazing; but those who work with the teams and who remain all day in the field with the relay teams are, for the most part, day labourers; and at each change the relays are brought to them by the herdsman. The expense of this man may be estimated at the value of 40 bushels of rye per annum. He can very well look after thirty oxen, and such a man must be kept even for a smaller number of beasts.

I am well aware that in many countries the maintenance of a servant is valued at a much less sum; but in the greater number of cases it will be found to amount to that now stated.

I shall now recapitulate the expenses of labour as performed by horses and oxen, and draw a comparison between them.

The expense of a horse is as follows:—

| | |
|---|---|
| Feed .......................................... | 449 ‡ |
| Interest of capital, depreciation in value, and shoeing | 86 |
| The harness and implements with which he works.... | 90 |
| A man to take care of four horses cost 400 ‡, consequently one-fourth, or 100 ‡, must be reckoned to each horse.......................... | 100 |
| | 725 ‡ |

If, then, 300 days' labour cost 725 ‡, each horse will cost 2·41 ‡ per diem. But if, during one-half of this time the horses work separately in two teams, so that the four require an extra day-labourer for 150 days, we must add 37·5 ‡ per annum to the cost of each horse, and consequently the value of a day's work will then amount to 2·54 ‡.

According to the four methods of feeding oxen, the expenses of which have already been calculated, an ox, if thoroughly well fed, will cost :—

| | |
|---|---|
| For feeding | 168½ ‡ |
| Risk | 12 |
| Harness for team | 22½ |
| Herdsman (reckoning this man at 40 bushels for 30 oxen) | 12 |
| Extra driver for 150 days | 62½ |
| | 277½ ‡ |

Two oxen working alternately therefore cost 555 ‡.

Thus, during the 250 working days, which is usually the average number in a year, the labour of two oxen working alternately will cost 2·2 ‡ per day. The labour of a horse costs 2·54 ‡ per day; that is to say, 0·34 ‡ more than two oxen working alternately. Local circumstance may easily modify this difference, rendering it sometimes greater and at other times less. It should be particularly observed, that we have here founded our calculations on the supposition that the oxen are better fed than they are in general, and we have also supposed them to do much more work than is usually exacted from them in our country.

In all those agricultural operations for which oxen are as well adapted as horses, two of the former working alternately will do more work than one horse; but there are many circumstances in agriculture in which the superiority of oxen is far less considerable; sometimes, in fact, it diminishes so much as no longer to compensate for the trouble of attending to two kinds of draught cattle, or for the inconveniences attending the use of two kinds of teams. For instance, on a farm which would require at least twelve horses, and where eight oxen might also be employed, it would be much better to keep four additional horses instead of the oxen; unless, indeed, the pasturage for the latter, and the care which they would require, should amount to very little.

The following are the principal kinds of labour performed with teams:—

1. *Ploughing.*—The data concerning the daily amount of work executed by a plough vary considerably. Some persons, from their own experience, state it to be 1½ acres; others, 2½; and some even 3 acres. All these data are founded on actual observations; but we must weigh and examine all the circumstances under which the observations were made, and which occasion this difference. The principal reason is the breadth of the furrow. If a plough cut furrows 6 inches wide on a surface of 30 Rhine-perches in extent, I shall have to make 720; but if, on the contrary, I make these furrows 10 inches wide, I shall only have 432. Supposing this surface to be 30 perches in length, the team will, in the former case have to travel over $10\frac{4}{5}$ geographical miles, and in the latter $6\frac{12}{25}$ miles, not reckoning the distance passed over in returning to the ends of the furrows. It should, therefore, always be borne in mind that the quantity of work which can be executed by one plough in a day is regulated by the width of the furrows or trenches.*

On land of a medium quality, the furrows are usually made 9 inches wide. In this case the plough passes over a surface of 14,400 perches, or $7\frac{1}{5}$ geographical miles, in the space of 5 acres. The turns will be more or less frequent, and, consequently, the distance passed over in turning greater or less, according to the length or breadth of the land which is to be ploughed; and 7½ miles may, however, be taken as the average in most cases. If, in consequence of this breadth of furrow, 2½ acres are ploughed in a day, the beasts of draught and the men travel over $3\frac{3}{4}$ miles, and this is the utmost that can be expected from them in continuous labour. The narrower the trenches or furrows, the smaller the extent of ground which can be ploughed in a day, and *vice versa.* It is likewise necessary to consider the nature of the soil, whether it is light or tenacious. The next thing to be considered is the depth of the furrow, in which every additional half inch, especially where the soil is heavy, often makes a very great difference in the resistance which it opposes to the plough.*

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* A Prussian acre contains only 3,053 square yards—a statute acre, 4,840.

Lastly, the construction of the implement is of considerable importance. A well-constructed plough overcomes the resistance of the soil much more easily than one of inferior construction; this may be particularly observed in argillaceous soils, and where deep furrows are cut; the cattle are less fatigued by a good plough, and they can move more rapidly and their progress is less impeded.

On light soils, where the friction is not very great, the ground is usually prepared by a horse hoe; this method facilitates the cutting of deeper furrows in ploughing.

After what has just been said, it will no longer be a matter of surprise to find such discrepancies in the reports furnished by practical agriculturists of the quantity of work performed by their ploughs. But it is, generally speaking, very necessary to make a distinction between the performance of the ploughs when particular attention is paid to them, at the times of press of work, and when the weather is favourable, and their average performance throughout the year.

This kind of labour and the moving power which it requires, will be enlarged upon when we treat of ploughing in particular. We will here admit that in the latter

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* PLOUGHING TABLE, BY MR. JOHN MORTON.
(*Farmers' Almanac, by Johnson and Shaw, Vol.* 1, *p.* 191.)

| Breadth of Furrow Slice, or Scarifier. | Space travelled in ploughing an acre. | Extent ploughed or scarified per day, at rate of | |
|---|---|---|---|
| Inches. | Miles. | 18 Miles. Acres. | 16 Miles. |
| 7 | 14⅛ | 1¼ | 1⅛ |
| 8 | 12¼ | 1⅜ | 1¼ |
| 9 | 11 | 1⅗ | 1½ |
| 10 | 9 9/10 | 1⅘ | 1⅗ |
| 11 | 9 | 2 | 1¾ |
| 12 | 8¼ | 2⅕ | 1 9/10 |
| 13 | 7½ | 2⅓ | 2 1/10 |
| 14 | 7 | 2½ | 2¼ |
| 15 | 6½ | 2¾ | 2⅖ |
| 16 | 6⅕ | 2 9/10 | 2⅗ |

part of the autumn, on what is called barley land, composed of equal parts of argillaceous and sandy soil, two acres per day may be well ploughed; and when the furrows are deeply cut to extirpate the harvest roots, an acre and three quarters per day may be ploughed. In the spring two acres may be ploughed for peas, oats, and the first barley-crops; and two acres and-a-half for the second. In breaking up the land to lie fallow, two acres; in ploughing the ground over again, two acres and-a-half; and in ploughing for seed, two acres and a quarter. These are averages which may be exceeded when the weather is favourable, or diminished when it is not propitious.

In general, a plough drawn by two good oxen, working alternately, will execute a quarter of an acre per day more than one drawn by horses.

2. *Harrowing.*—In this operation there are still greater differences in the amount of work done than in ploughing. In fact, every thing depends on the care and on the implements with which this important process is executed. Cross-harrowing is most efficacious, and also most difficult; and it is generally considered that sixteen acres is the utmost extent of surface which can be harrowed by a team of four horses in a day. Fourteen acres of tenacious lands infested with weeds, is a good day's work; but if it is only requisite to equalize, and not to break the clods, such a team can harrow twenty acres per day. If the operation is performed lengthwise—that is once up and once down—it is possible to harrow from twenty-four to twenty-eight acres per day with a team of four horses.

Horses are generally employed in harrowing, on account of the greater rapidity of their action; but oxen may also be used with nearly as much advantage.

3. *Rolling.*—This operation is generally omitted in the list of operations; it is, nevertheless, a very useful one, and adapted both to light and heavy soils. In proportion as the roll is broader and thinner, or shorter and of larger dimensions, the greater or less will be the labour

of the cattle in drawing it. Where the cylinder is eight feet long, it will be easy to roll eighteen acres per day.

Angular and pointed rollers, called spike rollers or clod crushers in England, are much heavier, and require more power to move them. Having spoken of those operations which are requisite in order to prepare the ground for sowing or planting, we will now proceed to notice those which take place during the growth.

To the former belong the tillage performed by the large double extirpator with eleven shares, by the use of which four horses and two men can finish eighteen acres per day; and that performed with the small extirpator, or sowing plough, with which one man and two horses can get over ten acres per day.

The trenching plough is also intended for operations of this kind, as by means of the mould-board attached to the coulter, it divides the trench horizontally into two parts, and throws the upper one to the bottom of the furrow. This implement requires an additional horse or ox in order to enable it to execute as much work as another plough. Two horses or oxen can draw it, provided that less work be required of them; and this latter method accords best with the habits of the animals. The implement is chiefly used for breaking up grass and clover lands.

To the second class of operations belongs the tillage performed withthe horse-hoe and the various kinds of rakes, "passauf," and cultivators drawn by horses, and by means of which one or two men, as may be most convenient, with one horse, can till six acres of land passing between rows two feet apart. Those ploughs which are intended for cutting deeper furrows in draining, have two mould-boards, which may be more or less separated at the hinder part, and these implements require two horses.*

The drill-plough for sowing seed in rows eight or nine inches apart will, when worked by two men and a horse, sow twelve acres a day; we shall, however, suppose the average to be ten, on account of the delays which sometimes arise.* The hoe with six shares, which is united with this implement, will get over from twelve to fifteen acres per day when drawn by one horse and guided by two men, according to the nature and condition of the soil, and the skill and practice of the labourers.

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* To this description of plough belongs an instrument for heaping the mould taken from the middle of the furrows round the plants sewn in rows.—FRENCH TRANS.

4. *The carrying of manure.* This operation, which in a well-conducted establishment is by no means inconsiderable, cannot be estimated with any degree of precision, except on a given locality; since it depends, in a great measure, on the distance of the fields, the state of the roads, the season of the year, and on the weather.

5. *Carrying the crops.* This operation also varies according to distance. Where relay waggons are kept, a team of four oxen will be sufficient for seven, eight, ten, twelve, and even sixteen waggons. A waggon load of corn is generally regulated by fifteens, scores, or fifties of sheaves; but as these latter vary in size in different places, in some districts weighing only eight pounds, and in others nearly fifty pounds, no positive rule can be deduced from this statement. During harvest time, when every operation is pushed forward, four good horses can easily draw 3,500 lbs. weight; and, provided that the waggons are of a proper size, the roads good, and the distance not too great, they may be made to draw 4,000 lbs. weight. If the sheaves are all of a certain size, it will then be easy to calculate what number of them will form a waggon load. In hay harvest, a waggon drawn by four horses will scarcely be able to carry twenty-two or twenty-four quintals, on account of

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* The author makes no mention here of the machines for sowing corn which are used in France and Switzerland, and which sow the seed in rows about five or six inches apart (from 14 to 16 centimetres). Although these implements extend over a space of 2½ feet or 81 centimetres in breadth, the greatest extent of land that can be sown with them by the aid of a single horse does not exceed four or five acres.—FRENCH TRANS.

the room it occupies; and as a great deal of time is lost in loading and unloading, and as this work cannot be commenced very early in the morning, it is impossible to get in more than six or eight waggon loads per day, even when the meadows are very near the homestead.

The operations of which we have been speaking, belong to particular seasons and times of the year; we will now proceed to mention others which are applicable to any seasons and may be performed in all kinds of weather.

6. *The carriage of grain and other product to the market towns.* It is generally allowed that 24 bushels of winter grains and peas, 32 bushels of barley, and 36 or 40 bushels of oats may be placed in a waggon at the same time. If the distance is about four or five miles, one day is allowed to go, another to return, and a third to load the waggon and sell its contents; if the distance be six or eight miles, three days and-a-half are allowed; if three miles, two days; and if two miles, one day. Thus, the distance of the market town makes a great difference in the performance of this operation, which is always exceedingly prejudicial to the teams.*

We shall now divide the year into four seasons, without, however, confining ourselves within the limits prescribed by the calendar.

Thus, winter comprises eighty days of labour, which may be employed as follows:—

Carrying manure for the fallow and vegetable crops, and breaking up some of the stubble fields, if the frost is not too hard to admit of it. After this is done, the teams may be used for any other purpose.

Spring comprises sixty-four days of labour, during which the following operations must be performed:—

Giving the second, third, and even fourth ploughing and harrowing to the fallow crops; giving the vegetable crops one ploughing; the barley one ploughing; the oats one or two ploughings. These two last operations may be in a great measure saved, or at any rate diminished by the use of the extirpator.

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* A German short mile is equal to 3·897 English.—Eds.

The newly-made dung must be carried to the last planting of the fallow crops, the winter corn harrowed, and those operations performed with the horse-hoe which are designed to encourage vegetation.

Summer, which commences somewhere about the month of June, comprises eighty days of labour, which may be thus employed:—

Ploughing the fallow ground for the reception of the winter grain; ploughing the stubble of clovers and leguminous crops the first time, in order to prepare for the autumnal seeds. Carting the manure destined for the winter crops; continuing the use of the horse-hoe from time to time; getting in the hay harvest, and reaping and housing the corn.

Autumn, which we suppose to commence in September, comprises seventy-six days of labour, and the following operations:—

Ploughing and harrowing the seeds; cutting and gathering the after-grass; getting in the potatoes and other roots, and also the cabbages; and breaking up the stubble-fields or pastures, not only for the reception of the seed of the following spring, but also for the dead fallow of summer.

Those who are accustomed to agricultural operations will be able to form an exact estimate of the number of teams which will be required, and to ascertain from calculation or past experience how many are necessary for the seed time of spring and autumn, in order to execute the work in four weeks or twenty-four days in the best possible manner. If a plough drawn by two horses can plough two and one-third acres of ground per day, and if four horses can harrow sixteen acres a day, a team consisting of four horses will be able to sow ninety acres per month; but if, on the contrary, from the tenacity of the soil, the increased severity of labour, when a greater depth of furrow is performed, or from the inadequacy of the force and slow motions of the horses, only two acres per day are ploughed, the number of those which are sown will be reduced to seventy-six. Thus, for each extent of ninety or seventy-six acres of spring or winter sowing (or, according to the most general usage, for every 112 or 95 bushels of seed) a team of four horses must be kept. In many countries a horse is kept for every *winspel*[*] of autumnal seeds. But when an extent of ground is sown with oats and barley equal to that sown with wheat and rye, and a quantity of vegetables and fallow crops is likewise cultivated, it will be impossible to execute all the operations incidental to spring with the same number of beasts as would suffice for the autumnal seed time.

## *Manual Labour.*

In some few agricultural undertakings, labourers are employed in those operations which are executed by oxen; when this is not the case, a herdsman can take care of twenty-four or thirty oxen; but where a still greater number of these animals is kept, he will require a lad to help him.

One cowherd is sufficient for fifty or sixty beasts, not only while they are at pasture—for then, with the assistance of a good dog, he might easily take care of two hundred—but also when they are in the stable, if some of the other domestics will assist him to cut the straw in the winter, and if the green fodder is cut and brought to him in the summer.

The number of female servants must be regulated by the number of cows that are kept, and also by the quantity of milk which these animals yield.

These servants are employed not only in milking and taking care of the dairy, but also are required to assist as much as possible in the cultivation of linseed, hemp, and other products, and in the harvest time: and in the winter they spin. When it is necessary to pay great attention to stall feeding, three female servants are allowed for every fifty cows, with one to inspect the others. In some countries, where great numbers of these animals are kept, one maid servant is allowed for every ten cows; but then she is expected to feed them and carry away their dung, two things which in moderately extensive establishments can be much better accomplished in another way. Most of the great cow-keepers in Holstein and Mecklenberg keep only one milk-maid for every twenty-five cows.

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[*] A winspel is equal to 24 bushels of English measure.

In large farm-houses, another female servant ought to be kept for the performance of the domestic affairs.

A man must also be kept to look after and take care of the pigs; this is not, as is generally supposed, so insignificant a duty that the execution of it may be confided to old women or to children.

We shall not mention the shepherd and his assistants until we come to treat of sheep, because the manner of using these servants and the wages which they receive vary greatly in different places. The shepherd is seldom included in the calculations of rural economy, excepting thus far, that he receives a salary either in money or in produce.

Besides the servants already mentioned, a bailiff or overseer is frequently kept, whose place it is to inspect all the operations, whether in the fields, the out-houses, or at the farm; to superintend the ploughing, the seed-time, and the harvest; and to use vigilance that all the labourers do their duty. He ought, also, to look after all the agricultural implements, and to be able to repair them and make new ones. In very extensive rural establishments, another overseer or bailiff is also kept, whose duty principally consists in making and repairing the carts' and waggons' work, and in superintending all the repairs and smaller buildings. Sometimes one or more extra farm servants are kept in readiness to assist in any operation for which they may be required; but, in general, day-labourers are preferred where it is possible to procure them.

Where these house servants are single, they generally live on the farm, and are boarded, lodged, and provided with every necessary article; but if they are married, they reside in separate habitations, and are allowed a certain quantity of provisions for their subsistence. The former are, certainly, most advantageous to the farmer, both as regards expense and the power of exercising a proper degree of surveillance over them. The greater the number of servants kept, the less is the expense of each individual one; for the cost of lodging, fire, candles, and even food, is almost as much for two or three as for twice that number. Where there are only a few servants kept, it might be advantageous to give to each one his allowance in produce.

There can be no doubt that the fewer married servants and those who receive their allowance in produce are kept, the better; for they invariably contrive that their whole family shall live at the master's expense, and are seldom or never satisfied with the provisions allowed them, although these may be far more than they could possibly require for themselves, but endeavour to carry off all that comes in their way; and it is no easy matter altogether to prevent their having the opportunity of pilfering.* Nevertheless, as some situations—those of bailiff, herdsman, and cowherd—require to be filled by steady, middle-aged men, and these are seldom to be met with unmarried, the farmer must, therefore, submit to the necessity of paying them their maintenance in produce.

No general estimate can be given of the expense of the keep of a man or maid servant, on account of the numerous variations which are produced by locality or by different customs. The difference of expense in one country or in another is so great as frequently to increase or diminish by one half. In general, however, it will be found, that where the servants are well kept, and particularly where they receive an ample allowance of food, they are stronger, more capable of work, and more willing to assist in all kinds of operations, so that the value of their labour is very little short of the actual cost of their keep. Accounts of the usages of many countries with regard to servants, and specifications of their expense in these places, will be found in many treatises on agriculture and political economy. None of these calculations are, however, to be depended on; the most correct are those by Count Podeevils à Gusow, in his work on political economy.

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* The author here prefers single to married labourers; the point admits much speculation, and, like most employments, the advantages of each are nearly balanced. It is evident that both must be employed; and while the necessity of having, on every farm, a ready command of labour is admitted, few farmers now-a-days like a number of servants living in the farm house. One or two seem useful, but a greater number is more advantageously removed to adjoining cottages. In our country, the single men on full wages are reckoned more expensive and much more troublesome than married labourers; and the author's observations about pilfering opportunities, are generally shifted to the other side. But our system of paying in a stipulated quantity of produce, to be used at pleasure, differs from the continental mode, where it would seem provisions are given for subsistence only, and exclusive of the value of labour. A somewhat similar custom yet prevails in the south of Scotland, where resident reapers receive a portion of grain in lieu of the evening meal, and thus is saved the trouble of cooking in the farm-house for that number.

According to an average rate deduced from observations made by myself in countries which are well known to me, it appears that the expense of the keep of a man-servant, a dairyman, or a cowherd, ought to be about equal in value to 34 bushels of rye, or 272 ‡; and the expense of a female servant, or lad, to 28 bushels, or 224 ‡: every necessary expense, as fire, candles, bed, &c., is comprised in this valuation. The difference is great in money, on account of the difference which exists in the price of provisions.

The wages in money likewise vary greatly; nevertheless they are generally more in accordance with the price of corn than with the nominal value of money: they may be estimated at 16 bushels of rye, or 128 ‡, for a man servant; and 12 bushels, or 96 ‡, for a female servant; and this will include linen, clothing, and other articles which she is to receive.

The wages of an overseer or bailiff are generally a little higher, and those of a cowherd a little lower, than those of the other servants.

Other workmen are paid by the day, or by the task; that is to say, for a certain quantity of each kind of labour; or, lastly, by a certain portion of the produce of their labour.

If the farmer would have his day-labourers do their duty, he must follow them up from morning to night, and look very carefully after them. The men earn much less when they work in this way, and, nevertheless, any work thus executed is far dearer to the farmer. In general, a day-labourer who is employed on some simple operation, and works a moderate time, will earn a bushel of rye in eight days, and, consequently, we may say 1 ‡ per day. Women and young persons, or feeble workmen, will only earn a bushel of rye in twelve days, or $0\frac{2}{3}$ ‡ per day; but this calculation is also liable to variations.

It cannot be denied that this last-mentioned kind of work (task-work) is by far the most advantageous both to the farmer and to the labourer, for then the latter will endeavour to get on with his work instead of trifling away his time and husbanding his strength. He will, of course, earn more than if he worked by the day, and, consequently, will be better fed, and able to procure many comforts, and to preserve his health and strength. He will, therefore, feel more interested in his work; will study how he can render the execution of it less difficult, will procure better tools, and acquire more skill, particularly if at certain seasons he is regularly employed in the same operations. His wife and children can frequently assist him, and by this means he will get on faster and train up his children early to work, and, by accustoming them to earn their own living, will thus relieve himself from some part of his responsibility.

So far from rejecting this mode of proceeding as some prejudiced agriculturists have done, because they feared that their labourers gained too much by it, although at the same time they could not help perceiving that the work done in this way cost them less money, a clever and clear-sighted farmer will not allow himself easily to be deterred from engaging his labourers by the task for performing all those operations, the value of which can, in some measure, be calculated beforehand. Thrashing is one of those operations in which the labourers are paid by a certain portion of the produce of the work; the thrashers generally receive the 14th, 16th, or 18th bushel of the produce. The same system is applied in some places to harvest; and in this case the reapers receive the 11th, 12th, or 13th sheaf for reaping and performing all other portions of this operation.*

In order to calculate the number of day-labourers or task-workmen which will be required in an agricultural undertaking, the following operations must be estimated, as being of most frequent occurrence:—

Ploughing with oxen or horses, if only one man is kept for every four-horse team.

Harrowing with oxen. When the number of horses is short, it occasionally becomes necessary to employ oxen at this work; likewise for waggons drawn by oxen, if there are no servants who can be entrusted to drive.

Manuring and ameliorations; carrying manure from the stables and cattle sheds; watering it, turning it, &c. Two men and-a-half will generally be required to load each dung cart, but this will, in a measure, depend on the rapidity with which the carts are driven backwards and forwards, the distance they have to go, and the compactness of the dung. The driver alone can generally unload the dung cart; if, however, several teams are used in the same cart, it will often be found advantageous to employ a man to assist in this operation, and, at the same time, to see that the heaps are properly distributed over the ground.

Spreading the dung on the land. It is generally admitted that a woman can spread an acre and a quarter per day, and a man an acre and a half or two acres per day. But this depends much on the quantity of manure which is to be spread, and on the state of it, and on the care which is taken to divide it as much as possible and distribute it equally. This last mentioned point is of so much importance, that no pains should be spared in attending to it. Manure containing much straw often requires to be thrown into the furrow with a rake or pitchfork, and this operation requires a man for two ploughs, and sometimes even for one.

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* The author much approves of task and piece-work in all cases where circumstances permit, though the utility is much disputed by many extensive practitioners, as tending, in most cases, to produce a careless performance of work on the part of the labourers, in order to realize more wages in a given time. For much of the detail work of a farm, task-work is unsuited, it is generally applicable in operations that require a very quick execution; and especially in cases that admit a regular and easy inspection; the preference, however, would seem to be yet undecided between labourers paid by the piece of work that has been satisfactorily executed, and workmen who perform, under constant inspection, an equal quantity. Our own opinion leads us to give the preference to task-work, wherever it can be adopted.

Sowing. This operation is usually performed by the head-man. It is generally reckoned that a man can sow eighteen bushels of winter grain and twenty-four bushels of spring-grain in a day.* A skilful sower can, in fact, sow much more if the extent be taken as a guide for the quantity of seed; this, however, depends on the thickness with which the seed is sown. It frequently happens that, when the seed is sown too thickly, with a view of getting as much as possible into the ground in the course of the day, a great quantity is lost. Attention should, therefore, be paid rather to the extent of ground sown than to the quantity of seed used; and if a man sows fifteen or sixteen acres per day, that should be considered as sufficient.

At harvest time, it is usually reckoned that with a cradle (a scythe furnished with rods for collecting the corn in heaps at the same time that it is cut), each man can cut and heap two and-a-half acres per day; a woman is supposed to be able to rake, bind, and collect two acres a day. Strong active people, who work hard, can, however, get through one-third more. The average amount may be reckoned as a little higher when an ordinary scythe is used. A man using a sickle may reap an acre a day. If the fields are not at a considerable distance from the farm-yard, the crop may be housed very rapidly by means of relay waggons; each waggon will require two men to load it and one woman to rake; but only one man beside.

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* A good seedsman with us will sow more than double this quantity.

Two men are required to unload and two to stack the corn when the crop is brought home quickly, besides three women for every ten feet of depth in the stack. If the waggons only return at considerable intervals, two men will often be sufficient. When the stubble is torn up with a horse-rake, one man and one horse can usually get through ten acres per day.

Hay harvest. An acre and a-half is the usual allowance for each mower, and the same for each haymaker.* When, as frequently happens, the meadows are at a considerable distance, the calculation must be made lower. The weather makes a very great difference in the number of people required for hay-making; in fine weather not nearly so many are needed. In mowing clover, where the land is very level and the clover has not been beaten down, two acres and a-half may be reckoned for each mower; and as the manner of executing the work is very simple, one labourer may be considered as sufficient for four acres.

The same number of men as are required for the corn harvest are usually allowed for loading and unloading, and half as many in the barn or hay-loft.

The methods adopted for the cultivation of the fallow-crops differ very much. If it be performed with the proper implements, and in a manner which is at once the best and the least expensive, one acre will employ the following number of labourers: two for sowing potatoes, one for rooting up those weeds which remain after the use of the horse-hoe, and one man and eight women for gathering the crop.

For sowing radishes and other small seed in rows: one man can sow five acres per day with a small sowing machine; and two men can, with the assistance of a horse, plough the furrows over twelve acres in a day.

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* These calculations must be made in reference to crops much lighter than the average of England.

Two persons, a man and a boy, are generally employed in sowing beans in rows, in order that the operation may be the sooner completed; they can get through five or six acres a day.

The weeding and thinning of radishes sown in rows should always be considered as task work. In these parts three pfennigs are paid for forty perches long, and the man who does this kind of work earns five or six groschen per day; consequently he thins about an acre per day.

If the farm servants are not sufficiently numerous to allow their feeding and looking after all the cattle, and especially if the cattle are partly fed upon chopped straw, some day-labourers must likewise be kept; the number, of course, will depend upon the peculiar circumstances of the establishment. Sixty or seventy days' labour are generally allowed for the washing and shearing of a thousand sheep.

Day-labourers are also required for various kinds of work in the farm-yard and the household, unless there is a superabundance of servants. It is also occasionally necessary to employ them in the room of those servants who are ill.*

For the cultivation of the garden, which we will suppose to be conducted on the simplest possible plan, and in which the female servants can be made to assist, five days' work of a man may be yearly reckoned for every acre.

For taking care of the ditches and trenches, repairing fences and damages of all kinds, and keeping the roads in order, from half a day to one day's work per acre all over the estate may be reckoned. This will, however, depend upon the extent and number of the fences, roads, and ditches.

It is impossible to form a general calculation of the amount of work which will be required for improvements, but the labourers may be employed on them at those times when there is least work to be done.

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* Some of the quantities of labour here mentioned as being performed by a certain power in a given time, are greater than the usual rates in our country, and many of them are smaller. Such differences will arise from local peculiarities of soil and climate, and also from the implements and mode of culture. Our shepherds would not require sixty or seventy days to wash and shear 1,000 sheep.

Threshing is usually considered as task work, and is paid for by a certain portion of the produce of the labour, generally a sixteenth part.

It is, of course, understood that these data are subject to variation, and that they may be increased or decreased by the skill and activity of the labourers, the manner in which the work is arranged, and many other causes. They comprise the work which may be expected from a day-labourer, but are by no means equal to what a strong active man can do, or what a labourer working at task work will perform.

We stated before, when speaking of draught labour, that if the teams were sufficiently numerous to get through the sowing time, they would suffice for the whole year; and so it is with regard to manual labourers, if the number is large enough to secure the harvest properly, they can accomplish all the other necessary operations. The labourers who have been employed at this season, may, in a large farm, be retained all the year round.

## THE PROPER METHOD OF KEEPING THE JOURNALS, REGISTERS, AND OTHER BOOKS CONNECTED WITH AN AGRICULTURAL UNDERTAKING.

A clear, precise, and accurate system of book-keeping is an essential feature in an advantageous and well-arranged agricultural undertaking. The most perfect system and the longest course of practice, even though acquired in the very place in which the cultivation is carried on, are rarely sufficient in giving an unexceptionable view of all its various relations and actual results. The farmer, in order to be convinced that he is really making some little progress towards the attainment of perfection, should always have before his eyes such a comprehensive view of the system as is naturally presented by well-kept books. In a too complicated system, the impressions of the senses and the recollections left by them seldom or never indicate the combinations which, on a former occasion, tended to produce the desired end, with sufficient exactness to be depended on; and, consequently, it is impossible accurately to say which were those that required to be modified or to undergo a complete change.

The system of book-keeping may be divided into two parts: the one permanent, the other annual.

To the former belongs what is called the *estate-book (livre foncier)*. This book should contain a plan of the whole estate and of each of its useful parts, and present a full, clear, and precise enumeration of every circumstance relating to it.

Above all things, this book ought to contain plans, with explanations of them. There are three sorts of plans: 1, The *geometrical plan*, containing the measurement of the surface; 2, The *geological plan*; and 3, The *plan of the distribution of the portions of land assigned to the different rotations of crops*, and the differences in the soil that cause the arrangement. In time, these three kinds of plans may be united; they are, however, designed for different purposes, although referring to one another; and it is therefore advisable to keep them separate and distinct.

1. The *geometrical plan* is merely a map of the extent of the surface, its permanent and natural divisions, and its limits. There is no reason, however, that certain notes and remarks should not be inserted in it, which may be useful; and the boundaries and the principal isolated trees may likewise be marked.

2. The *geological plan* shows the variations which exist in the nature of the soil. The various species of soil may be indicated on this plan by different colours, which will serve to show their extent, and to point out the places in which the nature of the soil is either suddenly or gradually changed. Where the variations in the nature of the soil are considerable, and the changes occur very near to one another, it is necessary that this plan should be drawn on a much larger scale than either the first or the third; and, in fact, that a separate sheet should be devoted to each piece of land. Such plans may be of very great assist-

ance to the memory in arranging the system of cultivation; but, for this purpose, particular attention must be paid to the degree of humidity of the soil, and the places in which the moisture is very abundant must be marked in a distinct manner, as well as those which are most hurt by drought. These plans should present the nature of the soil and its physical properties in every part of the estate at once to view, in the clearest and most obvious manner, and with mathematical accuracy.

3. The *plan of the distribution of the portions of land assigned to each rotation of crops.*—This plan contains the division of the estate and of its several parts, relatively to the kind of cultivation to which they are to be subjected. It should not be confined simply to the division of the crop-lands, but should extend to all the sub-divisions, particularly if they are to have any influence on the nature of the produce. It might, perhaps, be advisable to mark in it single acres or patches of land, where the expenses of the tillage, manuring, and sowing these portions are to be separately calculated. The numbers of the principal divisions may be marked on this plan in Roman numerals; and those of the sub-divisions, or of these pieces of land, in Italic figures, or by simple letters. A new series of numbers may be formed at pleasure for the fractions of each allotment of land, or the same series may be continued throughout all the pieces comprised in the estate. If it be desired to unite these three kinds of plans into one, that one must be formed upon a tolerably large scale, in order that each separate division may readily catch the eye.*

In many cases, and especially in very mountainous situations, where it is necessary to provide against water, it may be very desirable to have a levelling sketch taken of the land in various directions, and to exhibit the plan of it in a diagram. The nature of the beds on which the vegetable mould rests, and likewise those of the most remarkable of the lower strata, may also be indicated in this diagram.

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* The maps and plans here recommended by the author are essential to the proper management of estates, and form a striking contrast with the careless and unsystematic manner in which such means are generally used. A general cash-book and a geometrical map are usually kept from necessity, but the geological map and the book of rotations on the different soils, mentioned by the author, are found in some few instances only. The two latter are intimately concerned; and, when properly arranged and kept, are attended with much advantage. The map should exhibit the different strata, and all the variety of soils incumbent on them; and the book of rotations should contain a reduced geometrical map of each farm, facing on the opposite page a tabular form of the different fields, with the crops grown on each during every year of

To these plans tables should be affixed, showing the nature and consistency of the soil in each of the parts, and the distribution of the lands for crops. These things may all be comprised in one single table, which will thus give a clear and exact idea of them. If the division of the crop-lands be fixed and permanent, each division ought to have its own separate table. In the first vertical column there will appear the sub-divisions, with their numbers and denominations. Each kind of land should have a column assigned to it, in which the number of acres and fractions of acres which it contains should be indicated. The motives for classing the different soils should be stated by means of notes or references.

If, in the crop-lands, or their sub-divisions there should be any low places which cannot be sown, as bogs, ditches, roads, or other spots which will not admit cultivation, the extent of such places must also be specified; and the sums will then be taken both vertically and horizontally.

Besides this table, a separate description of each field should be drawn up, exhibiting all its peculiarities.

If every species of land be taxed for the purpose of affixing to each division and to every one of its subdivisions a price proportionate to the relative value, a summary will be obtained which will prove very useful in forming a valuation of the effective produce. Thus, after having previously deducted from the capital the value of all the rights and accessory revenues, indepen-

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the lease. The wood, on extensive properties, may be reduced to a similar form; and, by these methods, correct views can be at any time obtained of all circumstances relating to the estate, and very useful inferences and suggestions may be deduced for the future management and improvement.

dent of these lands, an estimate of the value of an acre of each sort of land is made according to the nature of the soil, and by the rules which we shall lay down when treating of agronomy, and, as far as possible, in proportional numbers; for example, the first class land may be estimated at 10, the second at 8, the third at 6, the fourth at 4, the fifth at 2, and the sixth at 1, if that be the proportion which they bear toone another.

The value of each division or sub-division of crop land is thus determined according to the quantity of each class which it contains, and this estimate may be used in forming a precise valuation of the net produce of each portion, as is the custom in England. It is generally known that the crop on any given surface is better in proportion as the soil on which it grows approaches the middling class.

In this valuation of the land, or rather in this division of capital among all the lands of which the estate is composed, some notice ought to be taken of other considerations totally foreign to the nature of the soil; thus, a field at a considerable distance from the farm buildings may be estimated at a much lower rate than one which is nearer, supposing them both to be of equal fertility.

The value of each portion of land thus determined may also be added to the table in a particular column.

It will be understood that meadows, pasture-lands, woods, mossy ground, and other useful kinds of land, should be included in the estimate as well as the arable lands, and their portion be charged in the distribution of capital.

With regard to the buildings, the value of which is usually added to the capital of the estate, if a separate value has been assigned to them, I think it most advisable to annex it to that of the lands which are in a state of cultivation, because it is for those lands that the buildings are required, and the latter are included in the conditions of the lease of the former. A complete specification and valuation of the buildings should be inserted in the *estate book*.

The *estate book* likewise contains an exact specification of all the useful and available rights that are attached to the domain, and the revenues both certain and casual which belong to it; such as statute-labour, tithes, leases of mills and taverns, incomes derivable from breweries and distilleries, or the right of having such establishments, and perhaps of supplying a whole district exclusively from them. The revenues are estimated according to their actual return, and the rights only according to the value which they would yield independent of risks, and supposing that they were farmed by another person instead of being exercised by the proprietor himself; for the profit which can be derived from a brewhouse, a distillery, or a mill used by the proprietor, is not so much the rent of the ground as the produce of industry. If such an establishment is really worked by the proprietor, a particular account of it must be inserted in the great book, and the rent alone which could be derived from it without the application of any labour, must be added to the capital of the estate.

The capital of the estate is composed of the united value of these different objects. If the amount of this capital be previously known, it must be distributed among the various branches according to their relative value, but not before a deduction has been made of all the liabilities of the estate according to the fixed or average value.

It will be found very useful to combine an account of the capital as well as an annual account of the cultivation with the estate book, in order to ascertain the return which the capital annually produces, and, consequently, the degree of augmentation which the property of the landlord acquires. According to the method of bookkeeping by double entry, the annual interest of the capital of the estate and of the stock are added to the debtor side of the account in the estate book, together with whatever may have been expended in money; and the amount of that which has been delivered to the proprietor both in money and kind, whatever has been expended in permanent improvements or ameliorations, or the additional value thus bestowed on the estate, is carried to the credit account. As the determination of the last object may, in some cases, prove rather difficult, it is generally considered sufficient to reckon the expenses occasioned by these improvements, or the value of the labour which has been devoted to them, even when that labour has been executed by means of the ordinary resources of the establishment. Since these improvements increase the capital applied to the estate, the interest of their value should be added to the ensuing year, but at a higher rate. Thus, for instance, if the interest of land be reckoned at 4 per cent., that of the improvements in question must be estimated at 6 per cent. This account in the *estate book* ought always to agree with that of the capital kept in the yearly ledger. It may be drawn up in the following manner:—

Debtor. ADMINISTRATION OF THE ESTATE. Creditor.

| | Rix-dol. | | Rix-dol. |
|---|---|---|---|
| 1843 to 1844. | | 1843 to 1844. | |
| Interest of 100,000 rix-dollars purchase money, at 4 per cent. .. | 4,000 | Paid to the proprietor. | 1,200 |
| | | Expended in improvements ........... | 3,800 |
| 1844 to 1845. | | 1844 to 1845. | |
| Interest of purchase money at 4 per cent. | 4,000 | Paid to the proprietor. | 3,500 |
| Improvements at 6 per cent.............. | 228 | Expended in improvements ............ | 2,000 |
| 1845 to 1846. | | 1845 to 1846. | |
| Interest of purchase money at 4 per cent. | 4,000 | Paid to the proprietor. | 4,000 |
| Interest of improvements, 5,800 rix-dollars at 6 per cent. .. | 348 | Expended in improvements ........... | 1,600 |
| 1846 to 1847. | | 1846 to 1847. | |
| Interest of purchase money at 4 per cent. | 4,000 | Paid to the proprietor. | 6,550 |
| Interest of improvements, 7,400 rix-dollars at 6 per cent. .. | 444 | Expended in improvements ............ | 800 |
| 1847 to 1848. | | 1847 to 1848. | |
| Interest of purchase money at 4 per cent. | 4,000 | Paid to the proprietor. | 8,500 |
| Interest of improvements, 8,200 rix-dollars at 6 per cent. .. | 492 | Expended in improvements ........... | 500 |
| | 21,512 | | |
| Balance due to the administration....... | 11,138 | | |
| | 32,650 | | 32,650 |

Lastly, the estate-book should contain a history or chronicle of the estate, to which may every year be added whatever tends to influence its value and its rights. One of the most important items in this chronicle is an account, embracing even the most minute details of every improvement that has been made in the property, and which has added to its value, as explained in a previous page. To this may also be added, notes relating to the price of produce, the weather and the fertility of different years, and, indeed, to everything connected with the estate, or which may be interesting to be kept in remembrance.

All changes of any importance, whether in the divisions of the land, in the buildings, or in the revenues and privileges attached to the estate, should be carefully entered in the estate-book, care being taken to class them all under their proper heads.

Remarkable facts, observations, and experiments relating to the cultivation of the land, may likewise be recorded in it, where a separate book is not kept for that special purpose.

A book of this description becomes a kind of treasure which a man may bequeath to his successors.

The second plan of agricultural books or journals contains the annual accounts of the whole undertaking, comprising the yearly account of the rural economy and the various matters relating to it. This system of accounts is complete in proportion as it extends to every portion of the establishment, embraces all the details which may tend to influence the whole, and exhibits each particular object with clearness and precision. It should, therefore, not only specify the disposal of the money and the produce in receipt and expenditure, but also contain details relative to labour, and all other matters which may tend to affect the success of the undertaking; as, for example, seeds, manure, &c. This system of accounts cannot be too carefully attended to and kept, as it is indispensable to the undertaking. The highest degree of excellence can never be attained without its aid: at all events, it is impossible without its assistance either to be sure of having attained the desired end, or to obtain a guide which will point out the path most likely to lead to it.

The following is the method usually adopted:—

Besides the *day-book* and the *note-book*, three *ledgers* are kept;

1. For the money accounts.
2. For the account of the receipt and delivery of produce.
3. For the buying, selling, and the profit or loss on the live-stock.

No. 1. The first part of the book containing the money account usually contains the receipts, and the second the expenditure. In both parts the pages are ruled in such a manner that the first column on the left may contain the date of the month and day; the second, the numbers of the vouchers if there be any; and the third, or middle column, the statement of the items; and the last two on the right, the cash accounts. In the first of the money columns, the various items are separately inscribed; in the second, the total receipt and expenditure of the month is inserted.

In order to explain the method more clearly, I shall transcribe the receipt of one month in the following table, whether arising from revenues in money or from the sale of rye:—

| Date. | Vouchers. | CASH RECEIPTS. | Rix | Gr | Pf | Rix | Gr | Pf |
|---|---|---|---|---|---|---|---|---|
| July 1. | | Balance in hand .................. | 210 | 16 | 8 | | | |
| | | For natural hay sold to —— of —— | 64 | 13 | | | | |
| | | For ground rent from the miller N— | 4 | 18 | | | | |
| | | For ground rent from the farrier G— | 8 | | | | | |
| | | For the letting out of land as potato ground, according to the account kept in the book for that purpose. | 12 | 12 | | | | |
| | | From the miller and farrier for money paid on their account to the fire-insurance office .................. | 6 | 18 | | | | |
| | | Total for July...... | .. | .. | .. | 300 | 3 | .. |

| Dates. | Wspl | Sch. | Metz. | SALE OF RYE. | Rix | Gr | Pf | Rix | Gr | Pf |
|---|---|---|---|---|---|---|---|---|---|---|
| Jan. 1 | 3 | | | To the miller N——, of ——, at 3 rix-dollars.................. | 216 | | | | | |
| 7 | | 16 | | To the bailiff ——, of ——, at 3 rix-dollars, 4 gr. ............ | 50 | 16 | | | | |
| 15 | 8 | | | To the corn-chandler ——, of ——, at 4 rix-dollars ........ | 768 | | | | | |
| 23 | | 1 | | To the day-labourer N——, at 4 rix-dollars.................. | 2 | | | | | |
| | | | | | .. | .. | .. | 1036 | 16 | .. |

The items of the receipts in cash vary according to the plan of operations which is pursued; they are united or kept separate, according as it may be required to have a more or less distinct view of each presented individually to the eye. Each part has, moreover, its peculiar title; they are usually classed under the following heads:—

1. Cash receipts, or revenues.
2. Sale of grain, each kind separately, as wheat, rye, barley, oats, peas, lentils, millet, and buck-wheat.
3. Clover-seed, flax, and other kinds of seed and produce destined for sale.
4. Fruits, and other garden and orchard produce.
5. Sale of cattle, horses, cows, oxen, calves, pigs, sheep, and poultry, each on a separate folio.
6. Sale of animal produce.:—
   (*a*) Butter, cheese, and milk, from the dairy and cheese-house.
   (*b*) Wool and lambs, from the sheep-fold.
   (*c*) Honey and wax from the bee-hive.
7. Sundries—occasional receipts which do not come under any of the heads, such as the repairs of damages, &c. &c.

If any brewery or brandy distillery should be attached to the establishment, and its produce sold, an account of it must likewise be kept; but where concerns of this kind are conducted on an extensive scale, it is customary to assign to them a separate set of books, and a separate cash-box.

The second part, or pecuniary disbursements, usually includes the following items:—

1. Payments to the proprietor, or on his account.
2. For building materials.
3. For builder's work.
4. For gardener's work.
5. For farm labour.
6. For labour expended on ameliorations and improvements.
7. For servants' wages.
8. For iron and nails.
9. For timber for use.
10. For fire-wood and turf.
11. For revenue in wood.
12. For horses.
13. For horned-cattle.
14. For pigs.
15. For sheep.
16. For farrier's work.

**17. For cartwright's work.**
**18. For locksmith's work.**
**19. For harness-maker's work.**
**20. For cooper's work.**
**21. For carpenter's work.**
**22. For customs and port duties.**
**23. For messengers, drovers, and travelling expenses.**
**24. For excise, turnpike, and city tolls.**
**25. For taxes, direct and indirect, poor-rates, &c.**
**26. For fire-insurance.**
**27. For produce consumed in the household and on the establishment.**
**28. For sundries, which cannot be ranged under any of the preceding heads.**

The annual summary of the receipts and expenditure in each separate month, and of each description of article or item, is best made in the form of a table, which may be readily formed by the farmer.

No. 2. The ledger for the receipt and delivery of produce accounts, has separate columns for the different kinds of grain, and in these columns the receipts and expenditure are balanced every month for the purpose of ascertaining the quantity remaining in the store.

In this manner, the table in question supplies the place of a barn-register; it is, however, usual to add to the amount of the receipts the produce not obtained from the harvest of the farm, such as corn purchased or received in payment of rent, &c.

Next comes the expenditure of the various kinds of grain classed under all the different heads. This account may as well be thrown into a tabular form.

The kinds of grain intended for sale may also be arranged in a tabular form.

The value in money may be given here by way of additional information; it is more fully and precisely stated in the money account.

Then should follow the other items of expenditure under their several denominations. Then the payments in grain, such as those appropriated to the physician, surgeon, veterinary surgeon, and chimney-sweeper; and lastly, the produce assigned for the consumption of the various persons employed on the establishment, such as the steward, foreman, cow-keeper, and shepherd, and also the farrier if an agreement can be made with him for shoeing the plough-horses.

The corn consumed by the plough-horses may also be shown in the form of a table. If the account only relates to an establishment which is the immediate property of the landlord, separate columns must be assigned to carriage and riding horses, and to those belonging to visitors. Corn given to other animals must likewise be taken into account, and entered in columns under the head of fattening of pigs and poultry. A separate column is devoted to the important object of the sowings of various kinds of grain, together with a memorandum of the day on which the seed was sown and the piece of ground occupied by it. Each kind of grain should have a separate folio.

The corn-account is usually terminated by a specification of the number of sheaves that have been gathered, and likewise of the barns and stacks in which they have been deposited.

After the receipt and expenditure of grain, there follows the account of other kinds of vegetable produce, such as meadow-hay, natural and artificial, potatoes, radishes, carrots, cabbages, hemp, flax, poppies, &c.

No. 3. The ledger for the account of the increase and diminution of the live stock, contains, in the first place, a specification and description of every head of cattle, with its name, number, the species or breed to which it belongs, its age, qualities and defects, and the value which it possesses at the termination or renewal of the early account.

The opposite page is left vacant for the insertion of observations, which it may be necessary to make upon each animal in the course of the year.

The condition of the other kinds of live stock should be stated, as far as possible, in the same manner.

Next may follow the account of the increase and diminution of the live stock, the numbers of which ought to correspond with those in the inventory of the stock. A separate account is usually devoted to the sheep-fold, in order that the increase and diminution of these animals may be visible at once. This is particularly necessary where the flock is composed of animals of different breeds, or where it contains some that are cross-bred.

Then may follow the account of the receipt and expenditure of various animal products; as, for example, what has been obtained, consumed, or sold, in butter, cheese, milk, wool, eggs, honey, wax, &c. The skins of beasts killed for home consumption, and likewise those of sheep that have died or have been killed, should likewise be entered in their proper places.

This method of book-keeping is, of course, subject to a variety of modifications. Every one may arrange it according to his personal convenience, or to the end which he has in view.

It constitutes, however, the system which is most approved at the present day, and is perfectly sufficient for all the wants of an ordinary system of agricultural operations. At the close of each monthly account, it exhibits a clear view of the whole; and as it may be supposed that every person who is employed to inspect a set of agricultural books must be more or less acquainted with it, a director will be better able to justify his conduct by it than by any other means.

The preference bestowed on this system, by many persons, on the plea that it is easier and more simple than any other, appears to me to be more founded on habit, and on the practice which these persons have had in the use of it, than on anything else. Besides, this system of book-keeping is by no means remarkable for simplicity, since it requires the use of several books and the double insertion of every item, and is by no means easy of reference. Besides, it does not give a clear idea or view of the details of the management and cultivation.

One of its greatest defects is the want of a simple and precise mode of reckoning in one of the most important objects of rural economy, viz., the application and division of labour; it is, however, possible to keep a book for this particular purpose. We shall very soon have to speak of the method of keeping an account of labour.

Before proceeding to the description of other modes of book-keeping, it will be as well to pause and endeavour to settle the question as to the time of the year at which the accounts should be opened or closed.

Many and very different periods have been selected for this purpose. The best is, undoubtedly, that in which there is a pause or rest, and when the greater part of the produce having been sold or consumed, the remainder can, consequently, be the more readily estimated. The usual commencement of the year is not, therefore, convenient; neither is the spring or the autumn, in my opinion, the proper season. Where I live, the 1st of July is the time usually chosen; and it appears to me to be on many accounts more suitable than those before-mentioned. I do not, however, like to see the hay-harvest thus divided into two parts, and therefore prefer the beginning of June; because, at that period, most of the things which require particular attention are in a state of rest; and there is then most leisure for a careful examination of the state of the provisions, the stock, and; indeed, of every part of the rural economy. There may, however, be many motives which will induce a person to conform in this respect to the usages of the country in which the estate he farms is situated, and particularly to that period at which farm leases usually commence and expire.

Where it is customary to sow small barley in June, the beginning of July certainly is the best time.

Although labour is one of the most important items in agriculture, much too little attention has frequently been paid to taking notes of it, and calculating the expense. Even if a general estimate be made of the cost of ploughing executed by the servants and teams belonging to the estate, as well as by day-labourers and taskworkers, and the whole amount of these expenses be obtained by adding together the wages and food of the servants, the value of fodder consumed by the beasts of draught, and, finally, the amount of pecuniary disbursements, still the portion of these expenses which appertains to each object, product, and field, is rarely ascertained with any precision; nevertheless, such knowledge is of the utmost importance, since it affords the only means by which certain results respecting the profit and loss of each department of the cultivation, or system of operations in general, can be obtained. Again, it is in this way alone that it is possible to ascertain whether the resources which have been expended on labour have been employed to the greatest advantage, or whether they might not be better applied. The method of which we are speaking would, likewise, tend to give a greater degree of control over labour than could be obtained by any other means, and to furnish data for making valuations on far more certain principles than could be derived even from the most incessant and careful superintendence and inspection of the different branches of labour.

For this purpose it is chiefly necessary to take note of the various works which have been executed, whether by manual labour or by teams, and the uses to which they have been applied. The method of making this entry is by no means unimportant; on the contrary, it is of the greatest moment, both as giving the utmost facility to the inspector, and, what is of more consequence, as furnishing him with the clearest possible summary of the labour devoted to each object, and enabling him afterwards to transfer it to the proper place without risk of error. I have tried various forms of this table of labour, and am of opinion that a weekly table is that which answers the purpose best. The one I use contains columns for four different classes of labourers, who receive a daily stipend of 6, 5, 4, and 3 groschen. These sums frequently vary from one season to another.

In the first column, the description and locality of all the operations executed during the week is entered. When it indicates the locality, or the purpose to which the labour has been applied, care must be used to make the note in the table agree with the title under which it will have to be entered in the ledger. Thus, those works of which it is desirable to have a distinct summary, must be entered separately in the table; while all those which are to be carried to the same account, may be collected together under one head. It requires some considerable degree of knowledge on the part of the inspector to form this combination properly; and, until this knowledge has been acquired, it will be better for him to make a number of distinctions rather than class too many subjects or objects under one head. At the beginning of the week he enters all those operations and works which he knows must certainly be performed; those others which he could not foresee, he enters, of course, in the order in which they occur. There can be no doubt that it is very desirable he should draw up a list or table of all the works which he knows must be executed; he will then only have to enter on every day the quantity of labour of each kind which has been expended upon every operation, in the proper column. The best way is to devote a book containing fifty-two pages to this journal, arranged in such a manner that the distinctions of heads will only require to be entered at the commencement of each quarter, and the divisions or columns are previously made.

Other persons may perhaps prefer having a black tablet, with horizontal and vertical lines drawn in red colours, and in such a manner as not to be effaced, suspended against the wall, and to mark the work which has been done each day upon it, and also the number of labourers employed in that work.

In the column which contains the summary, the number of labourers of each description employed during the week on each particular operation is inscribed; and in the money column the cost of each separate piece of work is entered. The total amount of days' labour of each description, and of the money expended, ought then to agree with the number of day-labourers and the sums paid to them as wages.

If a portion of the work has been executed by statute-labour, or by gratuitous service, an account of it must be entered in the proper place, and the value of it united with the rest. At the end of the week when the accounts are made up, these days of gratuitous labour must be separated from those which have been paid in money. The statute-labourers are considered as creditors for the number of days' labour which they have performed, and the sum is deducted from the whole amount which is due from them.

The daily account of labour executed by teams is kept in the same manner. Columns are assigned for each species of labour, separate ones being kept for the horses, the oxen, and the men who work with them. Each individual will be able to determine for himself whether it is best to make no distinction between or to separate the domestics who look after the horses, from those who take care of the cows. If the day-labourers work with the oxen and horses, their labour is entered in the table of manual labour and not in that of which we are at present speaking. The labour of beasts of draught is always better reckoned according to the number of head of cattle than according to the number of teams employed. At the close of the week a calculation is made of the number of the days of draught labour that have been applied to each operation; I think the money column may be omitted in this table.

From these weekly tables it will be easy to form a monthly summary of the whole accounts. There is, however, no occasion to confine oneself to a certain number of weeks: all that is requisite will be to rule the columns sufficiently long to comprehend the period which they are to contain. On an open sheet, there is always room for eight weeks.

For my own part, I find in the method of book-keeping by double entry so decided an advantage over the tabular form, that I feel very much inclined leaving to others the trouble of bringing the latter to perfection.

There can be no doubt that it is absolutely necessary to reduce everything to one common standard; and it would be scarcely possible to adopt any other than that of money, since it is to money that all the products of industry are ultimately reduced. Nevertheless, in the course of the reckoning, doubts frequently arise as to the value which ought to be assigned to some things which cannot be immediately realized. It is true, that a false estimate would make no difference in the final result, since what was lost to the credit of one division would be added to the debt of another; but this mode would lead to inaccuracy in the value of particular items. The average price of the greater number of articles—such, for example, as the grain and fodder consumed on the establishment—cannot be accurately determined in the course of the year, and at the time when they are used; and yet it is this price which regulates the valuation of other things which cannot be immediately settled in money—as servants' labour, and the labour of the beasts of draught employed in each particular operation; whereas, at the end of the year, a due consideration of all the circumstances and relations will lead, with some degree of certainty, to a knowledge of the value of each separate article in money.

Thus, for example, if I know at what value I ought to estimate the oats and hay consumed by the beasts of draught, and if I am also acquainted with the accessory expenses incurred by them, I can tell what a day's labour of a horse or an ox costs me, and can thus carry this sum to the debtor side of the account to which the operation belongs in which they have been employed; supposing, of course, that the number of days' labour has been accurately determined. In order to conduct a valuation properly, it is only necessary to lay down certain fundamental principles, and adhere faithfully to them. If, for example, any one should choose to take the average market price as the basis of his valuation of corn, I see no objection to such a course, provided that he also deducts from this price the expenses of transport, estimated by their actual value; including not only the wear and tear of the horses themselves, but also of the harness, and a certain degree of disorder among the men employed, as well as various other accidents and circumstances which experience alone can foresee and guard against. Thus, if, from a train of accidental circumstances, the market price should be raised considerably above the natural standard, that is to say, above what might be expected from the abundance of the harvest, I should fix the consumption price by that which the abundance of the harvest would give when uninfluenced by other circumstances; because those things which have tended to modify the natural price have not the slightest connection with my system of cultivation. I should likewise proceed on the same principles with regard to hay. As to those vegetables which are cultivated exclusively for cattle, as potatoes, turnips, &c., I should estimate their price at one and a-half times what they cost; that is to say, at one and a-half times the united value of the ground rent, the manure expended on them, and the labour employed in their cultivation. If the price throughout the neighbourhood should happen to become six times as high as its ordinary standard, it would make no difference to me or to the price which I had previously fixed upon the article in question appropriated to home comsumption, because I could profit little by this increase of price.

I have hitherto estimated the price of dung at one and a-half rix-dollars for a load of twenty quintals; I divide the total value between the cattle which have produced it and the straw which formed the litter of the animals to which it has been applied, assigning one-third to the cattle and two-thirds to the straw.

These are the principles which I have adopted for my own guidance with regard to the determination of prices, but, of course, every person is perfectly at liberty to modify them according to his situation and circumstances. When there is no cash receipt and expenditure, the produce is provisionally carried to each account in weight and measure only; and, at the closing of the account, its value is charged to the money column.

Most persons, who keep separate accounts of distinct productions, are in the habit of uniting together the same kinds of produce, although grown in different fields; but this method is not sufficient for me; I wish to know what each field has cost me, and what it has produced. In my books, therefore, each field has its separate account, and if two or more different kinds of produce grow in the same field, each of them has a respective account. This method causes no extra difficulty, if the daily accounts of labour are carefully kept. It must, however, be remembered that the greater part of the expenses of harvest belong to the preceding year's accounts, since the new year commences on the 1st of June or the 1st of July. But as it is necessary that the expenses and the produce should be contrasted with each other in the same account, the former are taken from the preceding year's accounts, either in one sum, or, at most, under the principal divisions; they are thus charged to the debtor side of the current year, and to the creditor side of the preceding year.

The produce of the various fields in grain is first debited to the barns in sheaves: but I do not value these sheaves until after the threshing is over, at which time I am able to ascertain the quantity of grain which they have yielded, and the price which should be affixed to it. The barn account should be kept in this manner, in order that it may supply the place of a barn-register; I know no other method by which the produce of each field can be kept separate, supposing that I am anxious to obtain an accurate knowledge of it: such care and nicety is, however, quite unnecessary for those who only wish to ascertain the gross amount of the produce. The quantity which the sheaves are found to yield after threshing is then placed to the creditor side of the barns, and to the debtor side of the kind of grain to which it appertains. It is better, at first, not to enter anything beyond the number of bushels produced, and to defer affixing the pecuniary value until the price of grain has reached the average height; and this amount may also be added to the general price adopted in that year for the rural economy: I shall call this latter the *cultivation price,* in order to distinguish it from the *current price* in the markets.

After the corn has been sold, the price actually obtained for it is entered, and the balance of the grain-account then shows exactly how much has been lost or gained in consequence of all the commercial circumstances.

The expenses that attach to grain, from the time of its consignment to the granary to that of its sale or consumption, cannot be charged conveniently to each particular kind; an account is, therefore, kept in the granary, containing, for example, the expenses of turning and cleaning the corn, and particularly the cost of transport. Should it be considered requisite or desirable, these expenses may be divided among the different kinds of corn in proportion to the quantity and pecuniary value.

There are also other matters which require particular accounts of cultivation and provision. The various expenses of cultivation are added to the debtor side of the former; and the produce, as it is brought from the field, to the creditor side. This produce is then, in its turn, carried to the debtor side of the provision account, the creditor side of which contains the use which has been made of the produce for various purposes. When, however, certain products are consumed as soon as they are taken out of the field—as, for example, clover and vetches given to cattle as green food, and a portion of the radishes —they are immediately charged to the credit of the field, and to the debt of the cattle by which they are consumed. The pecuniary value in this case is, indeed, rather uncertain; but I estimate it according to an approximate valuation of what the produce in question has cost me: some persons may, perhaps, think it better to estimate its value according to the utility and employment of the produce. In my opinion, the former of these two methods is far more advantageous than the latter, at least so far as the greater part of the agricultural establishments are concerned.

The live and dead stock are valued at the termination of each yearly account; a new inventory is then made of them, or the requisite alterations are made in that of the preceding year. The value of the stock at this period is entered in the following year under the proper heads. Thus, every improvement in the stock during a year is placed to the credit side of that year's accounts; while all the deteriorations, on the contrary, are charged to the debtor side. The account of live stock is debited with the price of whatever cattle have been purchased, and the cash account is credited with it, if the price has been paid in money; while the value of the cattle sold, or the sum obtained for them, is charged to the debtor side of the cash account, and the credit side of the live stock. When a beast dies, the value is debited to the account of the kind of cattle to which it belongs: as, for example, if it be a cow, the loss is added to the debtor account of the cow-house; and if it be a horse, the team account is charged with its loss. This is one of the parts with which beginners are most puzzled and staggered: it appears absurd to them to credit the live stock with the loss of all the cattle which die; and, indeed, the loss is productive of detriment to that stock, inasmuch as the value of it at the end of the year will be proportionably diminished. In this case, as in all others, it is only necessary that a person form a clear and just idea of this method of book-keeping, and he will easily be enabled to extricate himself from these difficulties, and others of a similar nature. The expression "Dr.," at the head of the debtor side of the account, is synonymous with "*have received,*" or, "*have benefited by;*" the expression "Cr.," on the opposite side, is equivalent to "*given away,*" or "*has furnished.*"

At the settling of the accounts, the sum total of all the items on the *debtor* side ought to be equal to the sum total of all those on the *creditor* side. But the debits and credits of the greater number of the accounts are very different; this is likewise the case with those which have nothing on the debtor, or nothing on the creditor side. The overplus of debt or credit in an account—or, in other words, the sum which must be added to one side in order to make it equal to the other, is called, in commercial language, the *balance.* It may also be termed *profit* or *loss, plus* or *minus.* If, then, the profit of all those accounts which have yielded any, be placed on one side, and the loss of all those which have sustained any on the other, the sum of these two accounts ought to be the same. But in order to ascertain the real return or profit of the undertaking during a year, it is necessary, in the first place, to add to the *general debit* of the account the loss on all those accounts which were necessary to carrying on the system of operations, or, what comes to the same thing, the expenses of the establishment; and, secondly, the credit of the preceding year.

On the other hand, the proprietor's debt, or the amount of that which he has drawn from the estate, whether in money or in kind; secondly, the debt of expenses attendant on improvements; thirdly, that of the following year; and fourthly and lastly, the debt of casualties and accidents which must be borne, not by the undertaking, or, what comes to the same thing, by the farmer—supposing the estate is farmed out—but by the estate itself, or by the proprietor (and, therefore, a special account should be kept open for the insertion of these casualties)—all these items must be added to the credit side of the account which is about to be balanced. The residue which is left, after one account has been deducted from the other, is the true nett profit or loss.

I should advise all those who may wish to adopt this method of book-keeping, to make trial of it for one year at first, and, during that period, to continue using the method to which they were previously accustomed, in order that their accounts may not be embarrassed and spoiled by errors which might not perhaps at first be discovered.

Whoever has once adopted this method, and entered fully into the spirit of it, will never afterwards give it up, or regret the trouble which it may have occasioned to him at first. The clear, precise, and accurate manner in which it demonstrates every result, not only of each particular part or operation of the rural economy, but also of the relations which the several parts bear to each other; the hints which may be derived from it for the improvement of the system of management and cultivation; the facility which it affords, and with which it enables any one to retain an absolute control over the agricultural operations and the consumption of food, even while in his own chamber, or while absent; and lastly, the indications which it gives of the various objects to which attention ought to be directed—all these will tend abundantly to compensate for the care which will be required in order to reduce it perfectly to practice, and particularly in the first year. During that period, the most difficult and, nevertheless, the most necessary part of the system, is to establish the day-books, and keep them in a proper manner; but here, also, the difficulty lies, not in the thing itself, but only in the ideas and principles which must be imparted to those persons to whom the keeping of the books is entrusted.*

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* The author has given a lengthened description of the systems that are adopted in keeping accounts in agricultural establishments, a subject that has obtained much attention in this country, and in which considerable difficulty has been experienced when attempted to be followed out to the extent of which it would seem to be capable. The system finally recommended by the author differs little from the most approved method in this country, in which every chief article and operation on a farm is entered in a separate account; that is, every article and operation that influences the conduct of the establishment, and the final loss or gain, and which it is necessary to exhibit in a separate form and disjoined from other contingencies. The result of each separate account appears in a money column, to which standard all values are reduced; and the balance of this column shows the profit or loss in the speculation.

The difficulty lies in determining the number of separate accounts, and in limiting the unnecessary multiplication of books. Some speculative writers have carried their ideas very far, and have proposed separate accounts for each field; but they involved themselves in valuations very difficult to be ascertained, and in calculations not required for the purpose in view. One book, called a "ledger," may comprehend each separate account in columns, and to which book all the other detached accounts will be carried. The number of the latter will depend on the nature and extent of the establishment: labour-books are indispensable, and beyond these two divisions, few concerns will require any more. A separate cash-book is now much used, containing every particular of the sums of money expended, and by which is seen the general state of receipts and expenditure of the whole business, without the trouble of referring to each separate head in the ledger. Many plans and books are proposed to be kept by amateurs, which are not required by the practical man; but every person who knows his business, and thinks on what he is required to do, will, as the author very judiciously observes, form a plan to suit the situation and circumstances, and for which purpose a careful study and examination of every plan published will afford materials of selection, as no single method can be devised which will be adapted to every circumstance of cultivation and locality.

## PROPORTION OF THE MANURE TO THE QUANTITY OF FODDER AND THE NUMBER OF CATTLE.*

The principal article which contributes most to the formation of the plants which we cultivate, which causes them to grow and to bear the seed which is destined for their reproduction, is manure, or the mould produced by its decomposition.

The quantity and quality of the plants which we propagate depends, therefore, on the quantity and richness of the manure which we can afford them. Next, then, to labour and the manner of superintending its execution, the subjects which most naturally present themselves to our consideration are, the nature of manures, the means of obtaining them, and the proportion between the quantity of the manure and that of the produce.

Attempts have been made to supply the place of manure by an increase of labour, or to supply the place of labour by an additional quantity of manure, but the success of these experiments has necessarily been merely apparent at first, and but of short duration. Jethro Tull imagined that he could altogether dispense with manure and replace it by the application of frequently repeated tillage applied to his crops, sown in rows, and by the complete division of the parts of the soil produced by that means. The plan, at first, turned out favourably for himself and his followers, for they had a fertile soil to work upon, which had for a long time previously been plentifully supplied with manure; in fact, by repeated tillage and the consequent exposure of the soil to the action of the air, all the nutritive particles contained in it were converted into extractive matter fit for the food of plants, and thus brought into the service of the roots and their fibres. But this effect can only last for a few years; and wherever this system of drawing upon the riches of the soil is closely followed, it will eventually render it so poor, that plentiful and repeated manurings will scarcely be able to restore it to anything like fertility.

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* In order to enter more fully into the views of the author, and, at his request, I have remodelled this chapter, so as to insert in it those observations and those modifications which were originally inserted in the beginning of the second volume of the German edition.—FRENCH TRANS.

There certainly are some kinds of land which are naturally so rich in themselves, and which have been so little impoverished by cultivation, that they do not require manure; but these are rarely to be met with, and form exceptions to the general rule; we shall treat of them more at length in the proper place. It very frequently happens that the degree of fertility possessed by any particular field or piece of land, and which is entirely owing to the land having been used as meadow ground for some time, and from a number of cattle having been kept upon it, is attributed to the nature of the soil.

Although nature furnishes a number of substances which tend to quicken vegetation, either by augmenting the vital principles or by assisting in the decomposition of the mould, it is only the mould or *humus* (finely divided organic matter) which is capable of the requisite degree of decomposition, or the vegeto-animal manures, which supply to plants the most essential particles, and those most necessary for their nourishment. I say their most essential particles, because they could likewise derive some nourishment from the decomposition of water as well as from the gaseous substances contained in the air, and from their combination; and that, if instead of removing the plants from the spot on which they grow, they were suffered to remain there and decompose and resolve themselves into earth, the operation of these principles would tend to increase and multiply the mass of vegetable products over the surface of the earth, or of any particular field. This fact appears to be demonstrated by the astonishing fertility of those soils which have never been cultivated, as, for instance, those of ancient forests.

With regard to that portion of the earth which cannot be decomposed, and which resists the action of fire, the experiments made by De Saussure and Schrader tend to prove that it has little to do with the positive act of vegetation, and only contributes to it by receiving the roots of the plants and preserving their nutritive matter, but is itself incapable of affording them sufficient nourishment for their support.

But as plants derive the substance necessary for their nourishment from the *humus*, or decomposing animal and vegetable matter, it of course follows that this matter must be diminished, and, in course of time, exhausted by the vegetation of plants in the soil; and the rapidity and degree of this diminution and exhaustion will be in proportion to the nutrition which these plants absorb, or, what amounts to the same thing, in proportion to the nutrition which they contain; supposing, however, that they are gathered and taken off the ground.

The strength of the vegetation and the quantity of each product is determined by the proportion of nutritive juices or succulent properties contained in the soil. By the terms "nutritive juices" or "succulent properties," we mean to designate that portion of the mould which is in a fitting state to be taken up by the roots of the plants, that which constitutes the richness and is the chief cause of the fertility of the soil; and we admit that the quantity of these juices is modified, augmented, or diminished by each product which is taken from the soil, because every crop we take from the field serves more or less to exhaust the fertility of the soil, and, unless we return it some equivalent in the form of manure, it will very soon become a barren waste.

The degree in which these nutritive juices are absorbed or diminished, is in proportion to the size, weight, and also to the nature of the produce. With regard to the whole class of cereals, both general experience and individual experiments tend to prove that the diminution is in direct proportion to the nutritive substances which these plants themselves, and particularly their grain, contain.

It is well known that wheat absorbs them and exhausts the land much sooner than rye, that rye exhausts it much sooner than barley, and barley much sooner than oats. Experiments commenced by many persons, and which are, in fact, hardly yet completed, demonstrate the existence of this proportion more clearly than could have been expected.

According to the best analysis that Einhof has formed of the different quantities of nourishing and succulent properties, as, for instance, gluten, starch, and mucilaginous sugar, contained in each kind of grain, there appears to be the following proportion:—

| | |
|---|---|
| In wheat | 78 per cent. |
| Rye | 70 |
| Barley, according to the qualities and species | 65 to 70 |
| Oats | 58; but the analysis of this kind of grain is not yet completed. |
| Lentils | 74 per cent. |
| Peas | 75½ |
| French beans | 85 |
| Windsor beans | 68½ |
| Horse beans | 73 |

| | | | |
|---|---|---|---|
| Thus, a bushel of | Wheat of | 92 lbs., contains | 71·76 of nutritive juices. |
| ” | Rye | 86 | 60·2 |
| ” | Barley | 72 | 48·6 |
| ” | Oats | 52 | 30·16 |
| ” | Peas | 100 | 75·5 |
| ” | Horse beans | 103 | 75·19 |

From these data, and by taking into account the differences in the nature of the succulent properties themselves, as well as in the straw and in the whole of the experiments relative to this matter, into which, however, we shall not enter until we come to treat of each product separately, we will admit that the crops of grain, properly speaking, bear the following proportions to each other as regards their nutritive principles and the degree in which they exhaust the soil:—

| | |
|---|---|
| Wheat | 13 |
| Rye | 10 |
| Barley | 7 |
| Oats | 5 |

| | |
|---|---|
| Thus, 6 bushels of Rye are equal to | 4·61 of Wheat |
| ” | 8·58 of Barley |
| ” | 12· of Oats. |

We ought therefore to expect that, when a certain quantity of nutritive matter is spread over a soil which, from its composition and physical qualities, is equally fitted to produce any one of the cereal plants, a crop of grain equal to this proportion will be produced; especially if, besides, we can ensure the existence of this equality united with cultivation and the temperature best adapted to the kind of grain that is used. This proportion generally exists in the crop; for, if at one time we obtain a more plentiful return than was expected, the following harvests will be proportionally diminished.

The relation of the produce to the exhausting property, has not, as yet, been determined with any degree of precision, excepting in those kinds of grain in most common use. As to other vegetable products, we do not, as yet, know any thing definite respecting them: the results are doubtless very different where these crops occur very frequently, instead of being used as intermediate or alternate products with separate crops of the gramineous grain-bearing plants. We shall not enlarge on this subject, until we come to speak of the succession of crops, and shall only observe here, that vegetables, peas, beans, and vetches have been regarded as ameliorating crops; and their possessing this property has been attributed to the shade which their leaves produce, the kind of culture they require while growing, which loosens the soil and keeps it clear of weeds, the air which they exhale, and the stem and large roots which they leave in the soil. Many persons have considered these crops as equivalent to a dead fallow, when they are not repeated too frequently in the same place, and when the plants are both vigorous and close together, which can only happen where the land is in good condition. Experience and theory, however, tend to prove that it is going rather too far to compare these crops to a dead fallow, which latter really causes an actual increase in the nutritive portion of the soil. The number of experiments on this subject which have been made on land cultivated according to the triennial rotation of crops, has induced a great number of agriculturists to think that, supposing the quantity of manure and the number of ploughings to be the same in both cases, the crop of autumnal corn and the spring crop by which it is succeeded will be about a bushel less in quantity than they would have been after a dead fallow. But ten degrees less of fertility will not explain this deficiency: it will require rather from seventeen to twenty degrees, for the rye will absorb five out of the seventeen, before it can produce a bushel of grain; consequently, if the fertility of the soil is diminished from seventeen to twenty degrees, the produce in rye will also be diminished by a bushel, and the spring crop will be reduced in proportion to the twelve or fifteen degrees which still remain to be used. For this reason I fix the positive exhaustion, or impoverishment occasioned by crops of vegetables, at ten degrees, and take that as a general average, without pausing to inquire whether the crop is plentiful or not; because experience teaches us that the finer the vegetation, the less does it impoverish the soil. Some attentive observers have remarked, that when the winter crop of corn was very fine and abundant after peas, the spring crop was proportionably poor; in these cases, therefore, they sowed oats instead of barley. Superficial observations have rendered the opinions exceedingly diversified with regard to the greater or less exhausting properties of other products. Many agriculturists assert, that potatoes deteriorate and exhaust the productive power of the soil very much; and adduce in support of this opinion the ill-success of the autumnal crop of corn which succeeds the potato crop: this assertion, however, generally emanates from those who sow their seed immediately afterwards, without any previous preparation, or without the interposition of any ameliorating crops—as turnips, or grass—and, consequently, when the land is in an unfavourable condition for the reception of grain. On the other hand, we meet with persons who cultivate the spring crop after potatoes, and are ready to maintain that it yields equally as well as the autumnal crops which succeed a fallow. It has been lately proved by several experiments, that potatoes, and other roots cultivated successfully, exhaust those soils which were previously in good condition but very little. This, however, seems to me to be carrying the matter too far: my own observations have led me to believe that two loads of manure per acre, each containing twenty quintals, will more than equal the impoverishment occasioned by a crop of potatoes; at least, wherever I have allowed this quantity, I have never been able to detect any diminution in the two crops of grain, viz., rye and barley, which followed. I must entreat all persons who have the opportunity, to pay attention to this subject. Here, again, there ought to be some difference made between the treatment of the soil after a plentiful crop, or after one which is not so abundant. If the potatoes are planted very closely together, they certainly produce a greater quantity; but then they cannot be so carefully cultivated: the fertilizing influence of the cultivation is, consequently, very considerably diminished, and the soil is more impoverished. I am, therefore, content with 80 bushels of produce, for the small quantity of five bushels of seed, per acre. Thus, I reckon the exhaustion which they occasion at thirty; attributing to them, on the other hand, the same fertilizing influence as that of a fallow, namely, ten degrees.*

The exhaustion or impoverishment occasioned by crops of grain may be repaired in three ways:—

In the first place, by the carrying and incorporation of manure, properly so called. The nutritive faculty of the soil is more or less augmented in proportion to the quality of this manure; and the goodness of the crop is also regulated by the same power, at least to a certain point; but beyond that, the manure becomes absolutely injurious, causing over luxuriant growth of corn. In forming an estimate of the amelioration or deterioration of the soil, we may regard a load of dung, taken at a suitable degree of fermentation, and weighing 2,000 lbs., as equal to ten degrees on an acre of land; and thus, five such loads of manure would be equal to fifty degrees.

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* The author, from experience, recommends the application of a small quantity of dung on land that has produced a crop of potatoes, in order to correct the (supposed ?) deterioration inflicted on the soil by that plant. Though he has applied dung on the supposition that the crop unduly exhausts the soil, he seems in doubt if the exhaustion be real or imaginary, and advises further attention to the subject. A long and very extensive individual experience, in which potatoes and turnips were cultivated on a great variety of soils, loamy clays, sands, and gravels, in the same field, and with the same management in every respect, never, in any one instance, shewed the least visible difference on any succeeding crop—wheat, barley, oats, or grass seeds; on the contrary, it is thought that all the crops, especially the last mentioned, thrive best on potato tilth, from the greater degree of pulverization which the land receives. Belief can hardly be given to the assertion, that a green crop, whose soil is manured, cleaned, and pulverised, can exhaust land more than two or three grain crops in succession: the current opinion must have arisen from attributing the effect to the wrong cause, and that opinion seems to have misled the author so far as to induce the application of an additional quantity of manure, without sufficient reason for such an application.

The nature of the manure must likewise be taken into consideration; we have here supposed it to be common manure, composed of the excrements of cattle, or of horses and pigs, and combined with straw or litter. The dung of sheep, especially that distributed over the fields by the pasturing of these animals on them, is not equally efficacious; it becomes more rapidly the food of plants, but it is also more quickly exhausted.*

Secondly, by what is called repose, or inactivity *(repos)*, or, rather, by the conversion of the fields into pasture grounds. The putrefaction of the herbage which grows spontaneously, of the worms and insects that lodge in it, and the excrements of the cattle which pasture on it, communicate to the soil a nutritive power, which is greater or less in proportion to the state of the land when it was left to nature, to the abundance and vigour of the vegetation, and to the quantity of excrements voided by the cattle.†

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* Experience will receive with limitation this observation of the author, that land is exhausted by heavy crops of esculent plants, and that it is enriched by thin slight crops from admitting more perfect cultivation. General observation would lead to a contrary conclusion in this country: in the case of thin straggling crops of any kind, the benefit imparted by the shade of close crops is wholly wanting, and exposure would seem to be detrimental. The quantity of seed allowed by the author to an acre of potato ground is only five bushels: the produce is sixteen from one, which is about an average crop in this kingdom.

† The crops of the farmer, if used in their green or unripe state, exhaust the soil which produced them in a much less degree than the same crops when suffered to ripen their seed; for their saline, and other matters, increase in proportion as the plants attain maturity. Now, the ameliorating grass lands to which our excellent author alludes are those fed incessantly by the live stock of the farm; the produce consumed green; the soil constantly enriched by the excrements of the cattle by which they are deposited.

This advantage may be fixed:

(*a*) According to an inverse proportion of the extent necessary for the whole maintenance of a cow.

| | |
|---|---|
| If 3¼ acres be sufficient, this amelioration may be considered as equal to | 10 degrees. |
| 3 — | 11 |
| 2¾ — | 12 |
| 2½ — | 13 |
| 2 — | 14 |
| On the other hand, if 3½ acres are required for a cow, the amelioration can only be considered as equal to | 8 |
| 4 — | 6 |
| 4½ — | 4 |

(*b*) Or according to the state of fertility in which the soil was allowed to grow herbage.

| | |
|---|---|
| If the soil contained 40 degrees of fertility, then it annually gains | 10 degrees. |
| — 50 | 11 |
| — 60 | 12 |
| — 70 | 13 |
| — 80 | 14 |
| — 90 | 15 |
| If, on the contrary, it only contained 30 degrees of fertility— | |
| — 30 | 8 |
| — 20 | 6 |
| — 10 | 4 |

When we come to treat more particularly of herbage, we shall enter more fully into an explanation of the method of determining the value of the pasturage, according to the degree of fertility contained in the soil.

The additional fertility which is produced by clover, varies according to the closeness of the crop, and the length of shoot which the plants are suffered to attain before they are buried by ploughing; and this latter circumstance has a very material influence on the improvement produced by clover. In fact, it is evident that when this plant is thick and averages from eight to nine inches in height, it yields a very considerable proportion of vegetable manure to the soil; but the thicker the clover, the greater will be this advantage, because then one ploughing will be sufficient. It may be laid down as a general principle, that clover sown on land containing 60 degrees of fertility, will improve it by 10 degrees; if the land contains 70 degrees, the improvement will amount to 12 degrees; if 80, to 14; and if 90, to 16, &c. &c.

The same may be observed with regard to vetches cut while green, if before burying them, they are allowed to stand and sprout again; but this second growth can only take place where the plants are thick and vigorous, and where they were mown just as they had begun to flower.

Thirdly, by a dead summer fallow, attended with proper cultivation; by means of which the soil will not only be cleaned and pulverised, but will likewise receive positive nutrition, as well from its different parts being successively submitted to the fertilizing influence of the gases contained in the atmospheric air, as from the putrefaction of the plants and roots buried in it by the operation of ploughing being hastened and expedited. The more vigorous and better the soil, the more efficacious does the fallow become; and in proportion as it has been complete, and the soil has been thoroughly cleaned, pulverised, and aerated, and the nutritive particles which it contained brought into action, will the subsequent crops be abundant. It is, however, a fact that in this manner a greater degree of exhaustion is subsequently created.

There is no doubt that the fallow absorbs or attracts the fertilizing properties of the atmosphere, and that the better the condition of the soil the greater is the quantity of nutritive particles thus absorbed; besides, the richer the soil the greater will be the quantity of weeds which spring from it, and the putrefaction of which will also contribute to ameliorate it. From these considerations we may conclude, that if the soil contains 40 degrees of fertility, the fallow will add 10 to it; if 50, the increase will amount to 11; if 60, to 12, and so on.

Every one must determine for himself, according to his own situation and circumstances, which of these three methods of improving the land will suit him best. Should he have succeeded in being able to procure an abundant quantity of manure from his own farm, he will, doubtless, find the first mentioned mode to be the most efficacious; but, unless that be the case, the other two may be advantageously adopted.

A field is seldom so much exhausted by the crops which it has successively produced as to be incapable of yielding any further produce. It may, however, be so much impoverished that the value of the crop will barely cover the expenses of cultivation. This faculty of production inherent in the soil is designated the natural fertility. There are different degrees of this fertility: when it is so high that an acre of land may still be made to yield two bushels of rye more than the quantity sown, and nevertheless must not be sown again from fear of exhausting it too much, until it has been manured or suffered to rest, or be fallowed, then its natural fertility is supposed to be equal to 40 degrees; and this is the greatest extent of exhaustion which a piece of land, of average quality, should ever be suffered to reach. Good barley land which does not contain more than sixty parts in a hundred of sand, a small quantity of lime, and perhaps about two parts in a hundred of finely divided organic matter, will seldom become so much impoverished, unless indeed it be purposely exhausted. When it has been manured once in six years, we always attribute to it 60 degrees of fertility, even though it may have produced four crops of grain; and we may then, if we choose yet further to exhaust it, also obtain other crops, care being used to choose those which will only require nutrition in proportion to this number of degrees. It is generally supposed that the more favourable the constituent parts of the soil to the reproduction of vegetation, the greater will this *natural fertility* be; and that, in proportion as the soil is of an argillaceous nature, it will be more difficult for it to be impoverished to that extent which we have here designated by 40 degrees, and, for the reason that it retains the nutritive juices longer, will produce less returns to cultivation, while it possesses within itself a richness which only requires to be brought into action by thoroughly dividing the integral parts which contain the nutritive and succulent matter. It requires a great deal of art thoroughly to exhaust land of this nature; but, when once it is done, an immense sum must be expended before it can be restored to a proper degree of fertility.*

This property of the soil which we term its *natural fertility*, because it is innate, and possessed by the soil at the time we bestow fresh nutritive matter on it, and particularly when we recommence the rotation or succession of crops, and forms the ground-work of the amelioration which we wish to produce—this fertility, I say, is increased or diminished according to the quantity of manure which is mixed in the land, and the number and kind of crops which are produced during the course of the rotation.

| | |
|---|---|
| Thus, if a field has received five loads of manure, each containing 20 quintals, for this must be allowed | 50 degrees. |
| For a dead fallow | 10 |
| For its natural fertility | 40 |

Thus, the whole amount of richness and nutrition may be valued at 100 degrees.

Others endeavour to attain the same end by means of trenching with the spade, acting on the belief that the under layer of the soil acquires additional fertility while it lies buried and inactive, and that when brought to the surface it will bear abundant crops; and they fancy that by changing the layer of the earth every year they shall ensure good crops, without being obliged to replenish the land with nutritive matter.

It certainly does occasionally happen that on some soils, where the layer which is turned up and brought to the surface is composed of a mixture of substances which contain combinations of oxygen and hydrogen susceptible of decomposition, this system appears to be successful for a time; but it will not endure for any length of cultivation, for after having produced a few crops without being manured, the land becomes so poor as to be incapable of affording the smallest nourishment to plants.*

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* The author thinks much art will be required in exhausting a certain kind of land, and very judiciously adds, that much more art, and also expense,

In the neighbourhood of large towns, where manure can be obtained at a low price, and in countries where, on account of the great extent of pasture lands, a large number of cattle are kept, little labour is bestowed on the ground; it is never suffered to lie fallow; the proper rotation of crops is not observed; the fields are sown with grain every year, and frequently with the same kind of plants. In those places, on the other hand, where, from want of fodder, a small quantity of dung can be obtained, the farmers seek to improve their lands by constant ploughing and cultivation, and particularly by allowing them to lie fallow, and either converting them into pasture grounds or leaving them perfectly inactive. This circumstance constitutes the great difference between the systems of cultivation pursued in Holstein and Mecklenburg, which are otherwise so similar. In the former country they manure the land very plentifully, and, in order to accomplish that purpose, they devote a considerable portion of it to the growth of plants destined for the maintenance of cattle; but they plough the fields very little, even for the reception of grain. In Mecklenburg, on the contrary, where the system of cultivation will not admit so much manure being expended on the land, the want of it is supplied by frequent, carefully managed, and complete fallows. Although this substitution may be practicable to a great extent, similar results must never be expected from it, since the greatest portion of produce can only be obtained when the soil, the manure, the labour, and the kind of grain sown, are in their relative proportions to each other.

And if we deduct from this sum the value of the impoverishment occasioned by the crops produced in the

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will be required in repairing the damage after the exhaustion has been effected. In this country, the art of exhausting lands is reckoned very simple, viz., by continued cropping, which will effect the purpose in a greater or less time, according to the degree of natural fertility. The art of restoring fertility to lands is naturally more difficult, and much aggravated by the expense, which mightily increases the difficulty of the art, though the processes be universally known. No farmer, who deserves the name, will ever allow such a result to happen on lands that are under his charge.

course of the rotation, the balance which remains will indicate the *natural fertility* of the soil at the close of the succession or rotation, or that number of degrees with which the ensuing course will commence. There can be no doubt that there is a certain regularity and proportion existing in the exhaustion occasioned by the crops. It is thus that, after a fine crop of autumnal corn, the spring crop generally proves meagre and scanty; and that, in the triennial rotation with fallowing, the autumnal crop in the second year, after a remarkably good crop of spring corn, will not be found to answer so well.* For the same reason, we see that a succession of abundant and scanty crops, the former having been favoured by weather and temperature, flourish and yield plentifully, but impoverish the soil very considerably; while the latter, having been retarded by unfavourable weather, leave more nutritive matter in the soil in which they vegetated than they originally derived from it. A careful examination and observation of this law of nature may lead to results which will enable us to obtain plentiful crops precisely at those seasons and in those years when, in the ordinary course of things, we should have obtained very bad ones; it may also teach us to reserve those powers which will overcome even the influence of unfavourable temperature for using in the latter periods. By this means, a generally bad year may be rendered exceedingly profitable by a skilful and scientific agriculturist. It is, therefore, evident that the fact of the same system of cultivation not being everywhere established and practised, is really a public benefit.

Until other, more numerous, and better authenticated experiments have been made, and all the light be thrown on this subject of which it is susceptible, we are led, from what is at present known, to believe that a crop of wheat will impoverish a fertile and not too cold a soil in 40 degrees; while a crop of barley will only exhaust 30 degrees, and a crop of spring grain 25 degrees.

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* The observation here made by the author, that a good crop of spring corn seldom succeeds an abundant autumnal crop, and *vice versâ*, is in exact accord-

When wheat is sown on a soil fitted for its reception, it frequently yields as large a quantity of grain as rye; and the produce not only weighs more, but also contains a greater amount of nutritive matter in the proportion of 13 to 10: thus, the proportion which exists between the degrees in which these two kinds of grain exhaust the soil, ought to be as 39 to 30; but as the impoverishment occasioned by wheat appears to be still greater, we will therefore suppose it to be equal to 40. With regard to the spring crops of grain, the short time their vegetation lasts must be a sufficient proof that the exhaustion which they occasion is much less; and, indeed, it is seldom that they yield in produce an equal quantity of nutritive matter with that furnished by the autumnal crops. For some time past, opinions have been divided in the question whether barley or oats are most exhausting; and the answer, doubtless, depends upon the state of the soil, the preparation which it has received, and the abundance of the crops of either kind which it has produced. On strong land which has received a slight ploughing, oats, which possess a greater capability of absorption, will exhaust more than barley; but then they will also produce a finer crop, and we therefore consider them to be about equal.

These data are not founded merely on the theory of the nutritive or succulent matters, but are deduced from a summary of the results furnished by general experience, and are in perfect harmony with those which have been observed in well directed agricultural undertakings, and which in average years are admitted in case of lands of moderate fertility. We only summon theory to our aid in this case to assist us in forming a standard or measure

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ance with the established fact that two grain crops should not follow each other. The following remark, that a bad crop of any kind enriches the land by not extracting so much nutritious matter as an abundant produce, is more difficult of admission in this country; and the meaning of the author is rather obscure how the skilful agriculturist can render a bad year profitable, and secure plentiful crops in adverse seasons, by any previous foresight or arrangement.

by means of which each product may receive an average value, always taking into account the various circumstances by which it is influenced; and the realization of this standard or measure proves, in its turn, the correctness of the theory.

Some of the more exhausting kinds of grain may occasionally, under the influence of favourable weather and temperature, yield a larger amount of produce than we have here assigned to them; but they will also impoverish the soil in a greater degree, and the succeeding crops will be proportionally less. All that is here attempted is to discover the sum total of the produce, and the greater or less degree of fertility retained by the soil.

In this hypothetical calculation I have endeavoured, as much as possible, to confine myself to round numbers, and to leave out all fractions; because these latter would only have rendered the calculations more difficult, without making any sensible difference in the results.

If we would calculate the probable produce of a crop of any single species of grain, according to the amount of easily soluble matter in the soil, we must take several accessory circumstances into account. When these accessory circumstances are favourable, a vegetable will yield a much larger produce from land possessing the same nature and degree of fertility than when the contrary is the case. These circumstances include a cultivation or preparatory crop which will destroy all the weeds which would otherwise prove injurious to the produce, and also those influences of the weather which we can neither foresee nor prevent. We ought, therefore, to have these circumstances constantly before our eyes while endeavouring to form an estimate of the produce, which, from the fertility of the soil and the nature of the grain, we may be led to expect; and to bear in mind that this attractive power can only be brought fully into action where it meets with no obstacles.

We have stated the average absorbing power of rye to be as 30 to every 100 degrees of soluble or succulent matter in the soil, and we shall now fix the produce of this kind of grain at six bushels besides the seed; thus allowing five degrees of impoverishment for every bushel.

According to the same principle, and to the proportion of the absorption of nutriment of the different kinds of grain, we ought to attribute

| | | | |
|---|---|---|---|
| To a bushel of | wheat | 6½ | deg. of impoverishment. |
| — | barley | 3½ | — |
| — | oats | 2½ | — |

and, consequently, to be able to calculate the probable number of bushels which will be yielded by a crop of each kind of grain on land of a certain degree of fertility, as well as the impoverishment of the soil which will ensue. In fact, we ought to be able to distinguish the exhaustive power possessed by a particular kind of grain, from the nutritious juices of the soil which it employs in its formation, for these two things do not always seem to be in absolute relation to each other. But the quantity of nutritious matter which a bushel of grain employs in its formation, is equal to the quantity which this measure detracts from the soil.

In order to explain what we have already said with regard to the proportion in which different kinds of grain exhaust the soil, we will give a few examples; and suppose, in the first place, that the soil contains 140 degrees of fertility. The exhausting power of wheat is 40 in 100.

100 : 40 : : 140 = 56.
A bushel of wheat absorbs 6½ degrees of fertility,
6·5 : 1 : : 56 = 8·6 bushels, which may be produced by these 140 degrees of fertility.
The exhausting power of rye is 30 in 100.
100 : 30 : : 140 = 42.
A bushel of rye absorbs five degrees of fertility,
5 : 1 : : 42 = 8·4.
The exhausting power of barley is 25 in 100.
100 : 25 : : 140 = 35.
A bushel of barley absorbs 3½ degrees of fertility,
3·5 : 1 : : 35 = 10.
The exhausting power of oats is 25 in 100.
All these quantities are exclusive of the seed sown.
100 : 25 : : 140 = 35.
A bushel of oats absorbs 2½ degrees of fertility,
2·5 : 1 : : 35 = 14.

Or, if the produce be known, and it is only requisite to obtain the quantity of nutritive matter which has been absorbed, we proceed in an inverse method. We will suppose 8 bushels of wheat, besides the seed: 1 bushel requires 6½ degrees of nutritive matter, therefore 52 degrees have been absorbed, and there only remains 88 of the 140.

If we suppose 8 bushels of rye, each bushel absorbing 5 degrees: these 8 will deduct 40 degrees from the 140, and only 100 will remain. Again, if we suppose 11 bushels of barley, at 3½ degrees, per bushel, these 11 will impoverish the soil 38·5 degrees, and there will only remain 101·5. And, lastly, if we suppose 14 bushels of oats, at 2½ degrees per bushel, this quantity will exhaust 35 degrees of the fertility of the soil, and leave 105. It depends upon circumstances, some of which are within our control and the others beyond its influence, whether the number of bushels thus reckoned from a calculation of the fertility of the soil and the exhausting properties of the grain will be realized, or whether the sum will be augmented; but, be the produce what it may, the impoverishment of the soil will be proportionate to the number of bushels of grain obtained.

As every thing relative to the doctrine which I am here laying down appears to me to be of sufficient importance to merit such a clear and precise explanation, as will help to obviate all possibility of misconception, I shall subjoin, as examples, some calculations relative to the augmentation, or diminution of fertility which is produced by the various rotations of crops.

| | |
|---|---|
| If the natural fertility of a soil be............ | 40 degrees. |
| And to this is added five loads of manure .... | 50* |
| | 90 degrees. |

And then, without being again manured, it is subjected to the triennial rotation with naked fallowing: it will present the following results.

In these calculations, I have intentionally deducted the quantity of seed sown from the product; therefore, if any one should wish to ascertain the sum total of produce, he must add the amount of the seed to the quantity here given. It is certainly probable that the seed contains a quantity of soluble matter, quite sufficient for a single reproduction; and that thus the increase of the quantity of seed, at least to a certain extent, always gives a much greater gross amount, although it does not yield any considerable increase of net produce.

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* A load of manure is here supposed to contain twenty quintals.—FRENCH TRANS.—A quintal is equal to 112 lbs. English.

| Rotation of the Crops. | Produce of the Crop over the Seed. | Succulent matter absorbed in Proportion to the Species and Quantity of the Grain. | Additional Fertility. | Remaining Fertility. |
|---|---|---|---|---|
| | bushels. | degrees. | degrees. | degrees. |
| 1. Fallow year.. | .. | .. | 10 | 100 |
| 2. Rye[*] ...... | 6 | 30 | .. | 70 |
| 3. Barley[*]..... | 5 | 17·5 | .. | 52·5 |
| 4. Fallow[†] .... | .. | .. | 11 | 63·5 |
| 5. Rye........ | 3·81 | 19·05 | .. | 44·45 |
| 6. Oats[‡] ...... | 4·44 | 11·11 | .. | 33·34 |
| 7. Fallow...... | .. | .. | 10 | 43·34 |
| 8. Rye........ | 2·6 | 13 | .. | 30·34 |
| 9. Oats ........ | 3·03 | 7·58 | .. | 22·76 |

Thus we see that the natural fertility of the soil, which, at first, was 40 degrees, has diminished to 22·76; consequently, it has lost 17·24; and this is the invariable result of that system of cultivation which, after an amelioration of five loads of manure per acre, exacts six crops of grain. In order to avoid this great exhaustion of the land, the rotation should have been interrupted after the fifth crop; but, by means of feeding cattle on the ground, it might have been made to bear the sixth crop, and, beyond this point, no person should ever go without manuring the land afresh.

Should it be thought desirable to sow peas on the manured fallow, in this rotation of crops—without, however, bestowing any additional quantity of manure—the peas will, as we have already observed, return some portion of the nourishment absorbed from the soil, but without producing the effect of a naked fallow. In this case the following will be the results:—

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[*] The 25 per cent. of succulent matter left in the soil by the rye crop, 17½ degrees, which, at 3·5 per bushel of barley, ought to produce 5 bushels.—FRENCH TRANS.

[†] 11, instead of 10, because that the soil has 52 degrees of fertility, instead of the 40 which it possessed at the time of the first fallow.—FRENCH TRANS.

[‡] The 25 per cent. of 44·45, that is to say 11·11, which, at 2·5 per bushel, makes 4·44 of oats.—FRENCH TRANS.

| Rotation of the Crops. | Produce of the Crop. | Nutritive Matter absorbed in Proportion to the Species and Quantity of the Grain. | Additional Fertility. | Remaining Fertility. |
|---|---|---|---|---|
| | bushels. | degrees. | degrees. | degrees. |
| 1. Peas …… | 5 | 20 | 10 | 80 |
| 2. Rye …… | 4·8 | 24 | .. | 56 |
| 3. Barley …. | 4 | 14 | .. | 42 |
| 4. Fallow …. | .. | .. | 10 | 52 |
| 5. Rye …… | 3·12 | 15·6 | .. | 36·4 |
| 6. Oats …… | 3·64 | 9.1 | .. | 27·3 |
| 7. Fallow …. | .. | .. | 16 | 37.3 |
| 8. Rye …… | 2·23 | 11·9 | .. | 26·11 |
| 9. Oats …… | 2·6 | 6·52 | .. | 19·59 |

Here the soil has lost 20·41 degrees of the fertility which it previously possessed. If, without augmenting the quantity of manure in this rotation, the farmer should choose to have a crop of potatoes instead of the first fallow, and if these roots impoverish the soil as much as a crop of rye, and nevertheless, from the culture they require, bestow on it all the advantages of a fallow, the following will be the results:—

| Rotation of the Crops. | Produce of the Crops. | Nutritive Matter absorbed in proportion to the Produce. | Additional Fertility. | Remaining Fertility. |
|---|---|---|---|---|
| | bushels. | degrees. | degrees. | degrees. |
| 1. Potatoes … | 80 | 30 | 10 | 70 |
| 2. Barley …. | 5 | 17·5 | .. | 52·5 |
| 3. Oats …… | 5·24 | 13·12 | .. | 39·38 |
| 4. Fallow …. | .. | .. | 10 | 49·38 |
| 5. Rye …… | 2·96 | 14·81 | .. | 34·57 |
| 6. Oats …… | 3·45 | 8·64 | .. | 25·93 |
| 7. Fallow …. | .. | .. | 10 | 35·93 |
| 8. Rye …… | 2·15 | 10·77 | .. | 25·16 |
| 9. Oats …… | 2.51 | 6·29 | .. | 18·87 |

It will here be seen that the soil has lost 21·13 degrees of the original fertility, and it is therefore still left more impoverished. It certainly is not usual to sow barley in the second year of the triennial rotation of crops in the place of rye, but it was necessary to do so here.

This example will tend to prove that the accusation of impoverishing the soil, so generally brought against potatoes, is not without foundation, since their introduction here not only diminishes the amount of all the crops which succeed them, but likewise increases the exhaustion of the soil.*

Where potatoes are cultivated as food for cattle, and are converted into manure, which is spread over the ground during the first fallowing, the results will be very different. But when potatoes are introduced into the triennial rotation, they are usually cultivated for a very different purpose.

| | |
|---|---|
| Supposing that at the commencement of a seven years' rotation with pasturage,† the soil possesses of natural fertility........ | 40 deg. |
| The usual quantity of manure is bestowed on it, making ...... | 50 |
| And that it becomes grass land for three years ................ | 30 |
| | 120 deg. |

the following will be the results:—

| Rotation of the Crops. | Produce of the Crops. | Nutritive Matter absorbed. | Additional Fertility. | Remaining Fertility. |
|---|---|---|---|---|
| | bushels. | degrees. | degrees. | degrees. |
| 1. Fallow .... | .. | .. | 13 | 133 |
| 2. Rye ...... | 7·98 | 39·9 | .. | 93·1 |
| 3. Barley .... | 6·64 | 23·27 | .. | 69·83 |
| 4. Oats ...... | 6·98 | 17·45 | .. | 52·38 |

Here the soil has gained 12·38 additional degrees of fertility, and commences the succeeding course of crops with this advantage.

Nine years' rotation with pasturage—

| | |
|---|---|
| Natural fertility.................................. | 40 deg. |
| Five loads of manure ........................... | 50 |
| Four years' pasturage ........................... | 40 |
| | 130 degrees. |

---

* In this tabular rotation and comparative statement, potatoes are shown to exhaust the supposed fertility of the land, and also to diminish the amount of the succeeding grain crops. This last result differs from the previous supposition that light crops left more nutritive matter than good returns; if it has been left in this case, it has been inoperative, though the land was fallowed and might be supposed to call it into action. But the assumption on which the whole calculation rests, viz., that a crop of potatoes exhausts land as much as a crop of rye, is purely hypothetical.

† *Siebenschlä gige Koppelwirthschaft.* In Germany the term "Koppelwirthschaft," signifies a system of cultivation, in which the crops of grain are succeeded or preceded by two or more years of pasturage, as is generally the case throughout Holstein and Mecklenburg.

| Rotation of the Crops. | Produce of the Crops. | Nutrition absorbed by the Crops. | Additional Fertility. | Remaining Fertility. |
|---|---|---|---|---|
| | bushels. | degrees. | degrees. | degrees. |
| 1. Fallow .... | .. | .. | 14 | 144 |
| 2. Rye ...... | 8·64 | 43·2 | .. | 100·8 |
| 3. Barley .... | 7·2 | 25·2 | .. | 75·6 |
| 4. Rye ...... | 4·53 | 22·68 | .. | 52·92 |
| 5. Oats ...... | 5·29 | 13·23 | .. | 39·69 |

Here, then, the soil is impoverished 0·31; the increase of produce yielded, is seemingly greater, but not real; this system has, therefore, fallen into disrepute, although once so much approved, and is now almost entirely abandoned.

In the rotation of eleven years with pasturage, the land is rarely manured with the first fallow; it, therefore, commences the course with no resources but the natural fertility, and the amelioration resulting from four years of pasturage, 80 degrees.

The results in this case are as follows :—

| Rotation of the Crops. | Produce of the Crops. | Nutrition absorbed by the Crops. | Additional Fertility. | Remaining Fertility. |
|---|---|---|---|---|
| | bushels. | degrees. | degrees. | degrees. |
| 1. Fallow on the broken up pasture ground. | .. | .. | 14 | 94 |
| 2. Rye ...... | 5·64 | 28·2 | .. | 65·8 |
| 3. Oats ...... | 6·58 | 16·45 | .. | 49·35 |
| 4. Fallow, with six loads of manure ........ | .. | .. | 71 | 120·35 |
| 5. Rye ...... | 7·22 | 36·1 | .. | 84·25 |
| 6. Barley..... | 6·10 | 21·06 | .. | 63·19 |
| 7. Oats ...... | 6·31 | 15·79 | .. | 47·4 |

Here the soil gains 7·4 degrees in eleven years.

Should we attempt to give examples of *complete alternate rotations,*[*] *with stall-feeding of cattle,* we must necessarily suppose that the quantity of manure applied to the crops, is far greater than that already specified; but the fertility of the soil always remains the same; in fact, unless it be possible to obtain an additional quantity of manure for the time, it would be folly to attempt introducing such a rotation, because the soil would very speedily be exhausted by the fallow crops.

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[*] *Assolemens alternes* (alternate rotations); it is thus that we designate the systems of cropping, in which one part of the crops is destined for the maintenance of cattle and the other for that of man. Thus, rotations with pasturage are properly called alternate rotations, although the successive crops of grain which are generally introduced are wholly at variance with the principles which ought to form the basis of "complete alternate rotations."—FRENCH TRANS.

We will, then, allow that, in a quadrennial rotation of this nature, one ought to commence by bestowing, at least, eight loads of manure per acre on the land during the first year; so that, with the natural fertility, the soil may contain 120 degrees.

| Rotation of the Crops. | Produce of the Crops. | Nutrition absorbed by the Crops. | Additional Fertility. | Remaining Fertility. |
|---|---|---|---|---|
| | bushels. | degrees. | degrees. | degrees. |
| 1. Potatoes .. | 80 | 30 | 10 | 100 |
| 2. Barley .... | 7·14 | 25 | .. | 75 |
| 3. Clover .... | .. | .. | 13 | 88 |
| 4. Rye ...... | 5·28 | 26·4 | .. | 61·6 |
| At the second rotation, ten loads of manure may be given. | | .. | 100 | 161·6 |
| 1. Potatoes... | 100 | 37·5 | 10 | 134·1 |
| 2. Barley .... | 9 | 33·52 | .. | 100·58 |
| 3. Clover..... | .. | .. | 18 | 118·58 |
| 4. Rye ...... | 7·11 | 35·57 | .. | 83·01 |

Thus, during these eight years, and in the course of the two rotations, the soil gains 43·01 degrees of fertility.

We will now give an example of some land submitted to an alternate rotation of the same nature, but divided into seven parcels.

| | |
|---|---|
| The natural fertility of which is ............................ | 40 degrees. |
| And to which has been added eight loads of manure............ | 80 |
| | 120 degrees. |

| Rotation of Crops. | Produce of Crops. | Nutrition Absorbed. | Additional Fertility. | Remaining Fertility. |
|---|---|---|---|---|
| | bushels. | degrees. | degrees. | degrees. |
| 1. Potatoes .. | 80 | 30 | 10 | 100 |
| 2. Barley .... | 7 | 25 | .. | 75 |
| 3. Clover .... | .. | .. | 13 | 88 |
| 4. Clover .... | .. | .. | 13 | 101 |
| 5. Rye ...... | 6·06 | 30·3 | .. | 70·7 |
| 6. Peas, with two loads of manure ... | .. | 20 | 50 | 100·7 |
| 7. Rye ...... | 6·04 | 30·21 | .. | 70·49 |

The soil has thus gained 30·49 degrees of fertility.

In order to be able more easily to compare the increase of fertility or the impoverishment of the soil, which are the results of these several rotations, we shall reduce the course to ten, and then we shall have the following results:—

| Rotations. | Increase of Fertility. | Diminution of Fertility. |
|---|---|---|
| Triennial rotation, with dead fallows and an amelioration of five loads of manure in nine years.............................. | .. | 17·24 |
| The same, with peas on the first fallow .... | .. | 22·67 |
| Ditto, with potatoes on the first fallow .... | .. | 23·47 |
| The seven years rotation with pasturage.... | 17·67 | |
| Nine years rotation with pasturage ........ | .. | 0·34 |
| Eleven years rotation with pasturage ...... | 6·73 | |
| The alternate four years rotation with stall-feeding.............................. | 53·76 | |
| Seven years rotation with ditto .......... | 43·53 | |

To this must be added the progressive increase of the manure, which takes place in all those rotations in which the general fertility is increased; and also the diminution which is daily visible in the manure in all those rotations which tend to decrease the fertility. Thus, the two latter rotations with pasturage, of which we have spoken, and which maintain a kind of equilibrium, may be continued for any length of time with equal success; whereas the others fall off, the former from exhaustion and want of manure, the latter from the excess of it, and require to be submitted, for a time, to some other course, or system of cultivation, which will tend to furnish the necessary supply of manure to the first, or absorb that overplus in the second which the regular rotations were unable to consume.

The triennial rotation of crops, as we have described it, absolutely requires an additional quantity of manure, or that the greater part of the fields shall only be made to produce a crop once in three years, and during the intermediate time shall receive one year's repose and a complete fallow. With regard to the alternate perfectionated rotation, it will be necessary to modify it by substituting vegetables intended for sale, for one part of the plants raised for fodder; because the former, by absorbing the superabundance of manure, will produce the finest and largest crop that can possibly be expected.

The quantity of manure here laid down is certainly only hypothetical, but we shall presently prove it to be that which is requisite for the second rotation. In the triennial rotation with fallows, it will be impossible to bestow a greater quantity of manure on the land than we have here stated, unless the farm contains a good portion of meadow and pasture land, or there are some other means of procuring manure within reach, or, lastly, unless recourse be had to the cultivation of clover, and to the stall-feeding of cattle. The rotations with pasturage may, and frequently will enrich the land much more than we have here calculated: and the same may be observed with regard to the alternate perfectionated rotations, whether united with pasturage or with stall-feeding.

As the system which I am about to mention appears to be, in my opinion, of sufficient importance to merit a clear and concise explanation, which may remove any misconception, I shall add as examples some calculations relative to the augmentation and diminution of fertility consequent on the systems of cultivation pursued in those agricultural undertakings which have been conducted on some of the best cultivated lands of Prussia.

I ought to observe, that in these tables the products in grain have been deduced from the results of actual experience, and not from those rules which I have already given; nevertheless, it will be seen that in general, and upon the whole, they are in tolerable keeping with each other, provided we commence at the second rotation of the course, when the soil has attained that degree of fertility which ought to be produced by this kind of cultivation.

In order to avoid useless fractions, I shall suppose the quantity of seed sown to be only a bushel per acre, and I shall subsequently deduct it from the produce, so as to be able to calculate the impoverishment which may be expected to ensue from the amount of the overplus.

### No. 1. TRIENNIAL ROTATION SYSTEM OF FALLOWING IN ALL ITS PURITY.

| | | Increase of Fertility. | Decrease of Fertility. |
|---|---|---|---|
| *a* | Fallow | 10 degrees. | — degrees. |
| | $6\frac{7}{10}$ loads (of 20 quintals) of manure | 67 | — |
| *b* | Rye, 6 bushels | — | 30 |
| *c* | Barley, 6 bushels | — | 21 |
| *d* | Fallow | 10 | — |
| *e* | Rye, 3 bushels | — | 17·5 |
| *f* | Oats, 4 bushels | — | 10 |
| *g* | Fallow, with a few cattle or sheep fed upon it | 28 | — |
| *h* | Rye, 4 bushels | — | 20 |
| *i* | Barley, 3 bushels | — | 10·5 |
| | | 115 deg. | 109 deg. |

The soil would thus gain an increase of 6 degrees of fertility in 9 years, were it not that the manure produced by this rotation is composed chiefly of straw, and consequently inferior in quality.

### No. 2. PERFECTIONATED TRIENNIAL ROTATION.

| | | Increase of Fertility. | Decrease of Fertility. |
|---|---|---|---|
| *a* | 6 Loads of manure | 60 degrees. | — degrees. |
| | Peas | — | 10 |
| *b* | 5 Bushels of Rye | — | 25 |
| *c* | Barley, 5 bushels | — | 17·5 |
| *d* | Fallow, with 6 loads of manure and a few cattle fed upon it | 90 | — |
| *e* | Rye, 7 bushels | — | 35 |
| *f* | Barley, 7 bushels | — | 24·5 |
| *g* | Clover | 12 | — |
| *h* | Rye, 6 bushels | — | 30 |
| *i* | Oats, 7 bushels | — | 17·5 |
| | | 162 deg. | 159·5 deg. |

Gained in nine years, 2½ degrees.

### No. 3. SEPTENNIAL ROTATION WITH PASTURAGE.

| | | Increase of Fertility. | Decrease of Fertility. |
|---|---|---|---|
| *a* | Fallow | 12 degrees. | — degrees. |
| | $5\frac{8}{10}$ Loads of manure | 58 | — |
| *b* | Rye, 7½ bushels | — | 37·5 |
| *c* | Barley, 7½ bushels | — | 26·25 |
| *d* | Oats, 7 bushels | — | 17·5 |
| *e* | Clover for mowing | 10 | — |
| *f g* | Pasturage | 20 | — |
| | | 100 deg. | 81·25 deg. |

Gained during the seven years, 18¾ degrees of fertility.

### No. 4. Rotation of Ten Years with Pasturage.

| | | Increase of Fertility. | Decrease of Fertility. |
|---|---|---|---|
| *a* | Fallow .......................... | 10 degrees. | — degrees. |
| | Three loads of manure .......... | 30 | — |
| *b* | Rye, 7 bushels .................. | — | 35 |
| *c* | Oats, 9 bushels .................. | — | 22·5 |
| *d* | Fallow .......................... | 10 | — |
| | 5 Loads of manure ............... | 50 | — |
| *e* | Rye, 7 bushels .................. | — | 35 |
| *f* | Barley, 7 bushels ............... | — | 24·5 |
| *g* | Clover for mowing ............... | 10 | — |
| *h i k* | Pasturage ...................... | 30 | — |
| | | 140 deg. | 117 deg. |

Gained 23 degrees in ten years.

### No. 5. Rotation of Twelve Years with Pasturage.

| | | Increase of Fertility. | Decrease of Fertility. |
|---|---|---|---|
| *a* | Fallow .......................... | 10 degrees. | — degrees. |
| | 3⅛ Loads of manure ............... | 31·25 | — |
| *b* | Rye, 6½ bushels .................. | — | 32·5 |
| *c* | Barley, 6½ bushels ............... | — | 22·75 |
| *d* | Oats, 5 bushels .................. | — | 12·5 |
| *e* | Fallow .......................... | 10 | — |
| | 6 Loads of manure ............... | 60 | — |
| *f* | Rye, 7 bushels .................. | — | 35 |
| *g* | Barley, 6 bushels ............... | — | 21 |
| *h* | Oats, 5 bushels .................. | — | 12·5 |
| *i* | Clover for mowing ............... | 10 | — |
| *k l m* | Pasturage ...................... | 30 | — |
| | | 151¼ deg. | 136¼ deg. |

Increase of fertility in twelve years, 15 degrees.

### No. 6. The Rotation of Ten Years as practised in Holstein.

| | | Increase of Fertility. | Decrease of Fertility. |
|---|---|---|---|
| *a* | Oats sown on the broken-up pasturage, 11 bushels .................. | — deg. | 37·5 deg. |
| *b* | Fallow .......................... | 12 | — |
| | 8 Loads of manure ............... | 80 | — |
| *c* | Rye, 9 bushels .................. | — | 45 |
| *d* | Barley, 9 bushels ............... | — | 31·5 |
| *e* | Rye, 4 bushels .................. | — | 20 |
| *f* | Clover for mowing ............... | 10 | — |
| *g h i k* | Pasturage ...................... | 40 | — |
| | | 142 deg. | 124 deg. |

Gained in ten years, 18 degrees of fertility.

### No. 7. Rotation of Eight Years with alternate Cultivation and Pasturage.

| | | Increase of Fertility. | Decrease of Fertility. |
|---|---|---|---|
| *a* | 9 Loads of manure ............... | 90 degrees. | — degrees. |
| | Potatoes ......................... | 10 | 30 |
| | 9 Bushels of barley .............. | — | 31·5 |

| | | Increase of Fertility. | Decrease of Fertility. |
|---|---|---|---|
| *c* | Peas | — deg. | 10 deg. |
| | 3¾ Loads of manure | 37·5 | — |
| *d* | 8 Bushels of rye | — | 40 |
| *e* | Clover for mowing | 12 | — |
| *f g* | Pasturage | 20 | — |
| *h* | Oats on the broken-up pasture ground | — | 27·5 |
| | | 165½ deg. | 139 deg. |

Increase of fertility in eight years, 30½ degrees.

### No. 8. ROTATION OF EIGHT YEARS, WITH ALTERNATE CULTIVATION AND STALL-FEEDING OF CATTLE.

| | | Increase of Fertility. | Decrease of Fertility. |
|---|---|---|---|
| *a* | 9 Loads of manure | 90 deg. | — deg. |
| | Potatoes, 80 bushels | 10 | 30 |
| *b* | Barley, 11 bushels | — | 38·5 |
| *c* | Clover | 15 | — |
| *d* | Oats, 13 bushels | — | 32·5 |
| *e* | 6⅔ Loads of manure | 66·66 | — |
| | Peas | — | 10 |
| *f* | Rye, 9 bushels | — | 45 |
| *g* | Green vetches | 10 | — |
| *h* | Rye, 8 bushels | — | 40 |
| | | 191⅔ deg. | 196 deg. |

Loss of 4⅓ degrees of fertility in eight years.

### No. 9. ROTATION OF TEN YEARS, WITH ALTERNATE CULTIVATION, STABLE-FEEDING OF HORSES AND CATTLE, AND TWO YEARS OF PASTURAGE FOR SHEEP.

| | | Increase of Fertility. | Decrease of Fertility. |
|---|---|---|---|
| *a* | Oats on broken-up pasture, 13 bushels | — deg. | 32·5 deg. |
| *b* | Green vetches on a fallow | 10 | — |
| | Pasturage of 1,500 sheep—per acre | 40 | — |
| *c* | Rye, 9 bushels | — | 45 |
| *d* | Peas | — | 10 |
| | 3 Loads of manure | 30 | — |
| *e* | Rye, 8 bushels | — | 40 |
| *f* | Potatoes | 10 | 30 |
| | 10 Loads of manure | 100 | — |
| *g* | Barley, 11 bushels | — | 38·5 |
| *h* | Clover | 15 | — |
| *i k* | Pasturage | 30 | — |
| | | 235 deg. | 196 deg. |

Increase of fertility during ten years, 39 degrees.*

Those agricultural systems, therefore, which are based upon this rotation are infinitely more ameliorating, and more likely to produce valuable crops of plants and vegetables, such as wheat, cabbages, and others intended for sale; they are also likely to increase the profits of sheep-husbandry very considerably, which would, doubtless, be much greater than they are at present if the breeds were improved and properly attended to.

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* The result of the rotation No. 9 shows the benefits of alternate cropping, as has been long ago proved in this country. The knowledge and use of green crops, esculent and herbaceous, must soon banish fallows from the foregoing rotations, for the growth of rye and barley would suppose a capability in the soil of being beneficially used in producing these invaluable plants.

The cases or situations in which a farmer can procure manure from any extraneous sources, independent of that produced by his own cattle and establishment, are of such rare occurrence that it is scarcely worth while to notice them at all in this place. Nevertheless, as they are frequently spoken of, although they can only exist in the neighbourhood of large towns, and as manure is often estimated at the price which it fetches under such circumstances, we will devote a few observations to the subject.

The only means of discovering the actual value of manure is to compare the produce of an acre of land which has been plentifully and repeatedly manured, with the amount which it yielded when only the necessary quantity of manure was bestowed on it, and that at distant intervals.

In the third volume of my English Agriculture, page 461, *et seq.*, I have given some account of this expense derived from information which I obtained from country people, and the results of which were that the real value of a load of manure was 6 rix-dollars and 9 groschen. But, in order to be convinced that it is correct after having calculated the produce of the triennial rotation, as given at page 147, let us suppose, on the other hand, that we could procure sufficient manure to enable us to bestow an amelioration of six loads every three years; and to avoid, as much as possible, diverging from the triennial rotation, we will take the following succession as a basis:—

1. Fallow manured.
2. Cabbage or turnips.
3. Wheat.
4. Peas manured.
5. Rye.
6. Barley.
7. Potatoes manured.
8. Barley.
9. Rye.

We must now calculate the value of all these products, according to the proportion of nutritive matter which the soil contains; and then, by deducting the extra expenses which cultivation of them occasions, the value of the manure will immediately become evident.

But the real value of manure is increased by the fact, that it progressively augments itself; and that, besides the produce it yields, an extra quantity of manure will, if properly bestowed, never fail to produce the elements of a fresh supply, so that it will soon be possible to cultivate those plants successively, from which the largest sum of money may be realized. On the other hand, the manure diminishes in like proportion if once a scarcity is allowed to be felt, and an immediate and suitable remedy be not found and applied. One of the consequences of a scarcity or diminution of manure, is a scarcity of straw; and where there is little straw or fodder, little dung can be obtained, and thus the quantity of manure progressively dwindles away until the soil becomes totally exhausted. However expensive it may be to bestow this first extra quantity of manure on a soil which has been impoverished, there certainly is no capital better employed than that which is expended in this manner.*

In order to prevent misunderstanding with regard to the quantity and weight or measure of this manure, we shall here lay down some principles, from which neither absolute uniformity nor mathematical precision must at all times be expected, but which may, however, be taken as general averages.

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* The author recommends the quantity of manure on any farm never to be suffered to grow less; and that some extraneous source be discovered, if possible, whence to support the quantity; and, finally, to create a progressive augmentation. If the crops be allowed to diminish in bulk, the quantity of dung will decrease proportionably, and end in the complete exhaustion of the farm. He observes that no expense must be grudged to fill with manure all the lands that are cultivated, and more especially on those soils that have been exhausted by previous mismanagement; and in the whole course of his writings, most certainly he has not made a greater or more valuable display of practical skill. On such lands the utmost limit of skill in cultivation and in cropping may be exerted, and with very little effect; years will be passed in a very heartless occupation, and time and labour will be expended with no corresponding result. On the essential expense that is required to produce the first crops, in order to yield the elements and means of raising others, most cultivators in our country stumble and founder, from want of calculation of the probable repayment; for, as before observed by the author, they cannot view capital as existing in any form other than in money in a bank or in coffers; and these contracted views produce a universal stagnation. Notwithstanding the many splendid examples of capital that had been judiciously expended, now repaying an ample premium on the amount, money employed in this manner is expended on the most solid security; panics and failures and bankruptcies do not affect it.

The usual load for a waggon drawn by four horses is thirty-six cubic feet of stable manure, half reduced, and in the state in which it is usually applied to the land. In this state—that is to say, when the straw has become soft and disorganized, without being wholly decomposed, and the dung is moist and yet not very watery—a cubic foot of it will weigh 56lbs.; therefore a load of thirty-six feet contains 2,016lbs., which, for the sake of obtaining round numbers, we will reduce to 2,000lbs. Where the roads are good and the weather favourable, this load may, doubtless, be increased; but as a period of fine weather is seldom chosen for carrying manure, this quantity will in general be found to be tolerably correct.

If the straw is not decomposed or altered, a cubic foot, closely packed, will not weigh more than 48lbs.; and in this case the volume or size of the load is increased, and contains from forty-five to forty-six cubic feet of manure.

When eight of these loads are distributed over an acre of land, it is considered that a good covering has been given: each square perch then receives 88·8lbs. of manure, and each square foot nearly 0·6lbs. If only five of these loads be allowed for each acre, as is generally the case, it is said then that the ground has been slightly manured, and each square perch receives about 55lbs. And lastly, if twelve loads are spread over each acre, which must never occur where cereal crops are to be grown, unless the land has been completely exhausted, then the ground is said to have received an abundant manuring.

It is customary to allow only one-half the weight and quantity above mentioned when the manure is derived entirely from sheep, because the effects which it produces are at once greater, more prompt, but less efficacious in point of durability.

The periods of these ameliorations occur every three, four, six, or nine years; the more frequently they are applied, the slighter they are; and the longer the intervals the more abundant must the manuring be, unless, indeed, scarcity compels the farmer to manure very moderately. Thus, in forming a calculation relative to the distribution of manure, it is necessary to take into account not only the quantity which is to be laid on at each separate application, but likewise the number of times that this amendment must be repeated, and the quantity which will be requisite for a certain number of years.

As it seldom happens that a farmer can procure manure in any manner which will prove cheaper or more advantageous than by deriving it from his own cattle and establishment, many persons have endeavoured for some time past to determine the relative proportions that ought to exist between the number of cattle kept and the extent of the cultivation of corn, in order that both may tend to produce the highest amount of profit which can be attained. The multiplication of the number of cattle raises the produce of the cultivation by increasing the quantity of manure which is made; and the ameliorations thus bestowed on the soil in their turn increase the profit of the cattle by augmenting the crops destined for their food. This reciprocal influence is the great balance-wheel of every well-regulated agricultural undertaking; and the least acceleration of its motion at any period, or the slightest inclination to one side or to the other, communicates itself to the whole machinery, and multiplies or diminishes the powers of action and their results.

In order to discover the just proportion of each of these objects in every locality, the persons before alluded to have commenced with the cattle, and have sought to determine how many of such a breed or species ought to be kept upon a given surface. One ox or cow has generally been considered as equivalent to one horse, ten sheep, or six pigs. But it was soon observed that there were great differences even between individuals of the same breed and kind, both as regarded the size of the animals and the quantity of food which they consumed; and that it was also necessary to take these circumstances into consideration. One of the most perfect calculations on this subject, founded on an average taken from several different data, will be found in Borgstede's work.* The author, in the first place, notices the straw and other component parts of the litter: he classes them thus:—

(1.) Countries in which straw is very plentiful, so much so indeed that, in general, from 1,500 to 1,800 sheaves of straw, and even more, may be reckoned for every winspel of seeds; a winspel of seed is generally equal to about twenty acres, which allows from 75 to 90 sheaves per acre, and the weight of a sheaf of straw of spring or autumnal corn is usually about 10⅔ lbs.; the whole will therefore amount to from 800 to 960 lbs.

(2.) Countries in which from 1,350 to 1,500 sheaves of straw are obtained for every winspel of seeds, from 67½ to 75 sheaves per acre, and about 720 to 800 lbs.

(3.) Countries which produce only a smaller quantity of sheaves, never amounting to 1,350, and in which there is consequently a scarcity of straw for litter.

(4.) Countries in which they are compelled to make use of other substances and extraneous matters, to supply the place of the straw as litter.

(5.) Countries in which they are able to supply this deficiency by straw purchased at a reasonable price.

In No. 1, the cattle are supposed to be turned into the pasture lands about the middle of May, and not taken back into the stalls until the middle of November.

In No. 2, the cattle are supposed to be turned out towards the end of March, and not brought up again until the middle of December.

In No. 3, the cattle are supposed to be fed entirely in the stalls.

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* Grundsatzen uber die "General verpachtungen der domainen in den preussischen Staaten," Berlin, 1785.

No. 4, indicates the dung resulting from 100 sheep, which were not pastured.

In No. 5, the animals are supposed to have been depastured during five months of the year, and confined in the sheep-fold all night during the other seven months.

Nicolai, in his work entitled, "Principles for the Regulation of Estates," says:—

One ox or cow yields 10 loads of dung, for a two-horse waggon.

One young ox or cow yields 5 loads of dung, for a two-horse waggon.

One horse fed in the stable yields 15 loads of dung, for a two-horse waggon.

One horse turned out to grass yields 7½ loads of dung, for a two-horse waggon.

One hundred sheep yield 100 loads of dung, for a two-horse waggon.

He likewise states, that half as much dung as is obtained from the horned cattle, may be derived from the pigs, the poultry, and the farm-yard, provided that care is taken to keep the latter place well provided with straw.

He allows twenty of these loads of the dung of cattle per acre, eighteen of horse dung, twenty-five loads of the mixed manure derived from the farm-yard, &c., and fifteen loads of the dung of sheep.

Consequently, an ox manures ½ an acre; a young ox or cow, ¼ of an acre; a horse fed in the stable, ⅚ of an acre; and a hundred sheep, 6⅔ acres.

These loads for two horses cannot contain 1,000lbs. because an amelioration of 20,000 lbs. per acre, would be something extraordinary. The system here mentioned of obtaining manure by strewing great quantities of straw about the farm-yard, is, in my opinion, very far from beneficial; as the fields, which were manured with dung thus composed, would derive little improvement from it.

Frédersdorf, in his "Valuations of Estates," reckons, that each cow that has been well kept, and has been allowed about 150 sheaves for litter, will produce six four-horse loads of dung; and if stall-fed during the whole year, that she will produce ten four-horse loads of dung. That each horse which receives a truss and a half of straw per day, will produce seven loads and a half of manure. He considers the dung of fifteen sheep, or of four or five full grown pigs, to be equal to that of one cow.

According to Karbe, sixty-five cows will manure a hundred acres, when they are turned out to pasture all day during the summer, and brought up to the cow-house at night; he states the proportion between horses or mares, and cows, to be as 2 to 3; and the proportion between stall-fed oxen as 3 to 2. A hundred sheep will manure ten acres.

Pfeiffer states, that a cow fed in the stall will yield 200 quintals of manure; and an ox put up to fatten, 80 quintals.

According to Leopold, four cows fed in the stalls yielded fifty loads of manure, six of which were sufficient for an acre of land.

In a paper by a very talented agriculturist, and a man of some experience in the "Annales de l'Agriculture de Basse Saxe," année 5, section 1, page 129, the following statement of the proportion of the quantity of manure furnished by different animals will be found:—

| | |
|---|---|
| If the dung of an ox or cow amounts to | 180 |
| That of a horse amounts to | 170 |
| That of a sheep, to | 10 |
| And that of a pig, to | 18 |

The manure produced in his undertaking during the space of three years, was distributed according to this proportion, and he found that

| | | |
|---|---|---|
| Each ox or cow had produced | 7·780 | loads for a waggon drawn by four horses. |
| „ Horse | 7·357 | — |
| „ Sheep | 0·432 | — |
| „ Pig | 0·778 | — |

These waggons, from the manner in which they were loaded, probably contained from 22 to 24 quintals each.

These data are strikingly vague, contradictory, and indefinite, leaving the many variations which occur with regard to the weight and bulk of a load of manure, totally out of the question; it is impossible to form a correct estimate of the quantity of manure which will be made by a certain number of animals, unless the quantity of fodder and litter consumed, and the manner in which the cattle are kept, be previously determined.

No average proportion can be given of the quantity of manure which cattle will produce, because when they receive an abundance of food containing a great proportion of succulent matters, the manure they will yield, both in straw and litter, and in excrement, will be seven or eight times as much as would be furnished if they were fed on dry food. In the former case, it is scarcely possible to give the cattle a sufficiency of litter; the dung ought to be carried out every day, or at least to be thrown back, otherwise the animals would stand in dirt and filth; in the latter case, on the contrary, straw which has formed the litter for a month or more, will be found to be scarcely soiled or wetted. The size of the cattle has some influence on the quantity of manure derived from them.

Cattle can only be considered as machines that appropriate a very small portion of the fodder which they consume to their own subsistence, while they reduce the greatest portion of it to dung. By dung, we understand not only the larger excrements properly so called, but also the urine, and perhaps some portion of the perspiration which is absorbed by the straw; this dung is not entirely composed of the residue of the fodder, but also contains some portions of the animal organization, which, in the course of nature, are detached, evacuated, and replaced by new formations. Thus the dung loses a great part of its vegetable nature, and acquires animal properties instead.

The experiments hitherto made have been insufficient to determine whether the mass of consumed and digested fodder is found to be augmented or diminished, when, by extracting the aqueous principle, it is reduced to a state of dryness.

It is most probably diminished, since the augmentation of the animal frame, the growth of hair or wool, and the secretion of milk, must absorb some portion of the aliments. It is, however, only a very trifling portion that is thus absorbed, and it is not yet decided whether the water which the animal drinks, and the gaseous substances which are otherwise imbibed, are not decomposed in the body until they form a solid matter. At any rate, it is certain, that by means of the additional humidity, the excrements weigh above half as much more than the dry food, if we weigh them in the moist state in which we use manure.

The superabundant moisture, particularly the urine, which we must not consider simply as water, but rather as a fluid containing a great number of very active solid animal particles: this moisture I say is absorbed by the litter, and thus augments the mass.

There is very great difficulty in determining the relative proportions which exist between the dung on the one side, and the fodder and litter consumed on the other. This accounts for the constant variations, trifling though they be, which are observable in the results of all the experiments made with a view of determining this point. There is still more difficulty and uncertainty in determining the bulk of the dung from that of the fodder, because the former depends on the greater or less degree of moisture and compression, as well as on the state of decomposition in which the straw, and other filaceous substances, happen to exist; all which circumstances have more effect on the bulk than they have on the weight. Nevertheless, the experiments hitherto made, whether on a small scale, by weighing the larger excrements by themselves, or in conjunction with the urine absorbed by the straw, or in all their various degrees of decomposition, or in that state when the manure does not give out any water, even from compression; or on a large scale, by determining as nearly as possible, by weight, the quantity of dung which is carried, and comparing it with the weight of fodder and litter consumed: these experiments, I say, are sufficiently in accordance with each other to prove that the mass of dry food and litter is rendered twice as heavy by the transformation into dung.

But, in order to produce this effect, the dung must be properly attended to, and as much straw used for litter as will be sufficient to absorb the fluids; for, should there be too much, it will not be properly impregnated with moisture, and, consequently, will not attain that increase of weight which was just mentioned: and should the litter be too thin and scanty, it will not retain the urine at all. The necessary quantity of litter cannot be determined by the number of cattle; it ought rather to be regulated by the quantity and quality of the fodder consumed, and the excrements produced from it.

Both the dry aliments destined for cattle, and those which have preserved their succulent properties, vary in nutritive powers, although they be of equal weight. (See *post* p. 168.) Thus, a greater number of cattle can be profitably fed on a certain weight of succulent food, than could be kept in condition by an equal quantity of dry fodder. Amongst cattle equally well fed, the larger excrements of those kept on substantial food frequently appear less bulky than of others fed on a greater proportion of less succulent aliments; but the quantity of larger excrements and urine voided by animals is not always in direct proportion with the amount of fodder which they consume.

A horse fed for the most part on corn will yield almost, if not quite, as much dung as one that consumes twice that weight of hay only. This is one reason that the nutritious properties and powers, as well as the weight of dry fodder, should be regarded; because what is wanting in quantity when the animals are fed on substantial fodder, is, doubtless, made up by the quality of the dung, and by the greater number of animal particles which it contains.

The worthy and talented commissioner, General Meyer, is the first writer who has given us an exact account, founded on well-attested experiments, of the quantity of dung which will be produced by a certain weight of fodder and litter. He gives to the straw the moisture which it derives from the urine, and, guided by these experiments, he supposes this increase to be as 2·7, when only the necessary and proper quantity of litter is laid down; and under the title of "litter," he also comprises the straw given as food, because it contributes little or nothing towards the nourishment of the animal. He allows only 1·8 for the augmentation occasioned by the moisture added to the hay which is consumed, on account of the nutrition derived from this kind of fodder by the animal frame. Those vegetables which retain their succulent properties are classed by him with the hay, but only according to their weight when reduced to a state of dryness. Lastly, he attributes a much greater augmentation to grain when transformed into dung, than they would derive according to the previous proportion; insisting that their weight is increased from 3 to 3·7.

According to the results of numerous experiments, and particularly of several trials which were made, with great care and precision, during the winter of 1808-9, on some oxen put up to fatten, it appears that we shall be very near the truth when we admit that the weight of hay and straw consumed, as well as that of litter just sufficient to absorb all the urine, will be doubled by its transformation into dung. The quantity of dung likely to be produced might be calculated with much more accuracy in this manner than it could be ascertained by any reference to the number of cattle.

We are left in still greater uncertainty with regard to the quantity of manure which may be obtained by feeding the cattle with a given quantity of succulent vegetables, because no satisfactory experiments on a sufficient number of animals, or continued for a sufficient period, have as yet been made on this point. Nevertheless, from several observations which I have had the opportunity of making respecting the use of potatoes, on extensive farms, where great quantities of this vegetable are grown and given to the cattle as their chief food, I find that, when transformed into dung, they lose at least two-fifths of their original weight, especially if the increase of weight above-mentioned be attributed to the straw consumed with them.

But this mode of proceeding does not do justice to the potatoes, for the chief part of the augmentation of weight in the straw proceeds from them; and without the aid of a good stock of these roots, fewer cattle could be kept, and there would, consequently, be a diminution in the supply of the urine, by which the litter is changed into dung and its weight increased.

With regard to the potato haulm or straw, according to an experiment made in 1809, an acre of that substance, which appeared to be thin or fine haulm, when cut and perfectly dry,

| | |
|---|---|
| Weighed ...................................... | 907 lbs. |
| A similar extent of large potato haulm, weighed .... | 605 |
| | 1,512lbs. |

The average weight would be 756 lbs.

The quantity of albumen which this haulm contains, renders it in general much preferable to straw.

There is no doubt that an accurate knowledge of the nutritive powers of different vegetables would enable us to form some tolerably close calculations respecting the quantity of manure which they would produce. Experiments have been made with regard to these nutritive powers, both in fattening cattle and by chemical analysis, and the results of both methods have been in accordance with one another. I therefore propose, at once, to begin and point out all the most essential facts with regard to the nutritive properties of the vegetables in common use, for this will be a necessary preliminary in order to render perfect those details of rural economy into which we shall have occasion to enter.

As hay is more known and more used than any of the other kinds of fodder, I shall make that article the standard by which all the others may be compared.

According to the researches of Einhoff, which he did not, however, regard as sufficiently accurate and complete to be submitted to the public, one hundred parts of good hay contain only about fifty parts of what may be regarded as nutritive matter.

If 100 parts of good potatoes, which are neither aqueous nor spongy, are dried to about the same degree as hay, after this process there will remain only 30 parts, and 25 of which may really be regarded as nutritive matter. Thus, in the feeding of cattle, 100lbs., or one bushel of potatoes, may be regarded as equal to 50lbs. of hay; and this proportion will be found to be borne out by almost all general observations made on the fattening of cattle; for when an ox put up to fatten receives 60lbs. of potatoes per day, he thrives equally as well as on 30lbs. of hay.

Beet-root contains only eight parts in 100 of actual nutritive matter: but it likewise contains four parts of filaceous substances, which is very difficult to decompose; and as it is yet uncertain how far these latter substances may contribute towards nutrition, we will suppose this vegetable to contain ten nutritive parts in every 100.*

The Ruta-bagas contain twelve parts in every 100 of matter decidedly nutritive, and rather more than three parts of filaceous substances, which are with difficulty decomposed. The turnip cabbage contains about the same proportions.†

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* I cannot comprehend how Einhoff could possibly distinguish which parts really were the nutritive portions of any vegetable, or how he could discover the actual degree of nutrition which these portions contained, unless it was by means of direct experiments on the feeding of animals; but I have strong reasons for believing that beet root is much more nutritious than the author has here stated. Leaving the assertions of the Abbé Rosier, which certainly are exaggerated, totally out of the question, I am led to believe from an account which there is in "La Bibliot Brit." No. 338, p. 42, of an experiment made in the winter of 1809-10, on twenty-four sheep, that 252 lbs. of beet root, if used two months after the gathering of the crop, will be found equal to 100 lbs. of hay. Subsequent experience has convinced me of the truth of this proportion.—French Trans.

† I was also induced, by the above-mentioned experiment, to believe that 234 lbs. of ruta-baga grown on argillaceous land, are equal in nutritive powers to 100 lbs. of good hay; 239 lbs. of raw potatoes, and 222 lbs. of these roots, when cooked, have also appeared to me to be equal to a quintal of hay; but

Thus 100lbs. of hay, 200lbs. of potatoes, 500lbs. of beet-root, and 370lbs. of ruta-baga, probably each contain an equal portion of nutritious matters.

These two last mentioned vegetables likewise produce a great many leaves; the leaves of the beet-root are most numerous, and contain the greater proportion of succulent matter, and are the most aqueous. Those of the ruta-baga, on the contrary, are fewer, but they contain more albumen,* and consequently are more nourishing.

If, in our valuation of these roots, we leave the haulm quite out of the question, and attribute no portion of weight to it, we may, without hesitation, admit that 460lbs. of beet-root, and 350lbs. of ruta-bagas, are equal to 200lbs. of potatoes, and 100lbs. of good hay.

Einhoff has not completed his analysis of these vegetables. Nevertheless, after a very superficial examination, and comparing them with the ruta-bagas, he came to the conclusion that with regard to nutritive properties, their reciprocal relation was as 2 to 3. Thus, 525lbs. of roots, would be equal to 100lbs. of hay.

The same may be said with regard to carrots, which really contain a great number of aqueous parts, and also a great deal of albumen and sugar. We are enabled from the experiments of Einhoff, as well as from the observations of different persons while employed in fattening cattle, to ascertain that their relation to potatoes is as 3 to 4; thus 266⅔lbs. of carrots are equal to 100lbs. of hay.

White cabbages have not as yet been analysed; but, from the experiments which have been made with regard to fattening cattle, their proportion, when compared with potatoes, is as 1 to 3: thus 600lbs. of white cabbage are equivalent to 100lbs. of hay. Clover, if cut at the period when its flower is just opening, loses 80 parts of 100

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as all the crops of this vegetable grown in 1809, were, evidently, very aqueous, I can agree with the opinion of Einhoff on this point. I also perfectly coincide in his opinions with regard to carrots, lucerne, and clover.—FRENCH TRANS.

* A substance of the same nature as the yolk of an egg.

in drying; but both experience and chemical analysis tend to prove that this plant contains a far greater portion of nutritive juices than hay grown in natural meadows, and that the stalk in particular, like that of all plants belonging to the diadelphous class, contains a great deal of albumen and sugar. 90lbs. of young, dry clover may consequently be regarded as equal to 100lbs. of common meadow hay.

Vetches, if cut when young, bear about the same proportion; if they are suffered to grow older, the increase of size on the one hand, and the formation of the husk and seed on the other, compensate for the diminution of succulency in the stalk and leaves. Neither can we give any reason that the same value may not be assigned to lucerne and saintfoin. It does not, however, appear to me that we have any proof that these plants lose nothing by being dried, or that they contain the same quantity of nutritive matter when reduced to dry fodder, as they did while green; in fact it is exceedingly improbable that no portion whatever, excepting the water, is evaporated during the process of drying; but it possibly might happen that the fibrous parts which could before be easily decomposed, have become more difficult of dissolution.

We may then consider that for feeding cattle the following proportions will be found to be equally nutritious and beneficial:—

| Hay. | Potatoes. | Beet-root. | Ruta-baga. | Radishes. | Carrots. | White Cabbage. |
|---|---|---|---|---|---|---|
| 100 lbs. | 200 lbs. | 460 lbs. | 350 lbs. | 525 lbs. | 266 lbs. | 600 lbs. |

| Young Clover. | Vetches dry. | Lucern dry. | Saintfoin dry. |
|---|---|---|---|
| 90 lbs. | 90 lbs. | 90 lbs. | 90 lbs. |

In order the better to attain our object, and to ascertain the proportion between the quantity of nutriment which may be obtained and that of the dung which it will produce, it is necessary that we should previously determine the average amount of plants and vegetables which may be raised on an acre of land, always supposing that a proper kind of soil and a suitable degree of cultivation are employed. We shall enter more fully into this subject when we come to the part of the work that is more especially devoted to what relates to these vegetables; and there we shall describe the basis on which the valuation given in the preceding section is founded.

At p. 27, we divided meadow land into five classes, by taking the greater or less amount of produce which it yielded, as the basis of the classification; these divisions will be more accurately and precisely defined in the sequel. Meadow land of the first class is seldom met with; and, as a meadow must be in very tolerable condition to enable it to yield 1600lbs. in two crops or mowings, we will take this quantity as the average produce.

It is frequently reckoned that the clover crops will produce from thirty to forty cwts. of hay per acre; but the soil must be particularly rich, fertile, and calcareous to yield this quantity, although it is argillaceous in constitution.

On a common argilo-sandy soil which has been deeply and carefully ploughed, which is submitted to a judicious rotation, and on which the clover is properly sown, an average crop of 2400lbs. at two mowings, or 1600lbs. at one cutting, may in general be confidently reckoned upon, and five times that weight in green fodder. In moist and fertile years, when both crops are equally good, the produce of the clover will far exceed this average; but in dry years, when one crop is scanty, it will frequently be far below it.

Rich and thickly planted lucerne ought to yield 4000lbs. of dry fodder if the soil and climate be suitable for it. Saintfoin, if sown on a soil appropriate to its nature, will yield 2000lbs. of dry fodder per acre. Vetches, or the mixed crop of which they form a portion, will yield at least 2000lbs. of dry fodder when they have been manured. When they have not been manured, and the soil is nevertheless in good condition, this produce is reduced to 1200lbs.

A crop of potatoes, sown on a warm soil, which has been deeply ploughed, well manured, and has received a very careful culture, will yield 80 bushels per acre, or 8,000lbs. over and above the seed. The amount here mentioned is rather below than above the average produce of a good and carefully cultivated soil; I have, myself, repeatedly raised a crop of 12,000lbs. per acre in ordinary years. But I would rather that my valuation of this, and of all other crops of roots, should be below their average produce than above it,* in order to do away with the suspicion, which many seem to entertain that I speak more favourably of them than they deserve, from having a predilection for that root.†

| | |
|---|---|
| Beet-root yielded | 20,000 lbs. of roots per acre. |
| Ruta-baga and turnip cabbage | 20,000 lbs. |
| Carrots | 18,000 lbs. |
| Cabbages, if sown on a soil suited to them. . | 36,000 lbs. |

Thus, then, the produce of an acre of potatoes may be regarded as equal in nutritive power to ........................ 4,000 lbs. of hay.

| | | |
|---|---|---|
| That of an acre of | beet-root as equal to | 4,847, or 4,300 |
| ,, | Ruta-bagas | 5,700 |
| ,, | Radishes | 3,800 |
| ,, | Carrots | 6,700 |
| ,, | Cabbages | 6,000 |
| ,, | Clover, at two mowings | 2,600 |
| ,, | Lucerne | 4,400 |
| ,, | Saintfoin | 2,200 |
| ,, | Vetches, when manured | 2,200 |
| ,, | Ditto, not manured | 1,300 |

In every case I have supposed these vegetables to be grown on a soil which is suitable to them, and which has been for some considerable period ameliorated by careful culture, and has been properly manured. It must also be understood that these products are calculated from an average taken from several successive years, since there always will be seasons in which some of the crops turn out badly, and others, on the contrary, in which they yield far more than the usual amount of produce; this consideration ought also to induce us to cultivate several different kinds of crops, in order that the gain on some of them may compensate for the loss in others.

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* The crop of potatoes at 80 bushels beyond the seed, or 100 bushels, seems very low; and, allowing the German to be two-thirds of our acre, the crop will only amount to 150 bushels; and the scheffel being about one and a-half bushels, the whole amount little exceeds 200 bushels.

† These weights are much below the usual produce in England.

If we collect the excrements and urine of those animals which have been fed on plants or vegetables containing a great proportion of succulent matter, and keep them separate from any other substances, we shall, doubtless, find that this dung will bear more relation to the nutritive powers than to the weight of the food. The lesser weight of the more solid aliments will be compensated by the greater quantity of water which the animals will drink while consuming them. Thus, 200 lbs. of potatoes, 350 lbs. of ruta-bagas, 600 lbs. of cabbages, or 50 lbs. of oats, will singly produce as much dung as 100 lbs. of hay; for each of these quantities will afford an equal degree of nourishment to cattle. But if we allow the excrements to be collected with the straw, and attribute to it, and not to the excrement, the increase of weight which the latter derives from the liquid portions, the proportion of these will be modified. Those aliments which contain the smallest portion of indissoluble fibres, will yield the least quantity of large excrements. This accounts for the fact that exceedingly succulent vegetables do not stand in that proportion to hay, with regard to the dung which they produce, as they do with regard to nutritive properties.

We have not, as yet, had any sufficient or definite proofs of the quantity of dung produced by most of the vegetables given as food; the only experiments from which clear and certain results were deduced, are those which have been made on potatoes. It would appear, from the average of those results which I have stated at p. 172, that 100 lbs. of potatoes will produce 60 lbs. of dung; and that thus, an acre of potatoes which yields 80 bushels, or 8,000 lbs. above the seed, and is equal to 4,000 lbs. of hay, will produce 4,800 lbs. of dung, without reckoning that produced by the haulm, which amounts to 1,512 lbs., on account of the weight being doubled of that portion, when reduced to a state of dryness. It will weigh this amount whether it be given to the cattle as food while green, or dried and used as litter instead of straw. Therefore, by uniting these two sums, we shall find the average amount of dung produced by an acre of potatoes, to be 6,312 lbs.

As experience has not, hitherto, furnished us with any data from which we can derive any positive information with regard to the other plants used for fodder, we will suppose their produce in dung to be equal to that of potatoes, calculated not according to weight, but according to the number of acres, without allowing anything for the additional quantity of nutritive matter their extra amount of produce may contain.

We shall, likewise, suppose clover and lucerne to be the same in this respect as natural hay, notwithstanding the superiority which they possess over the latter in point of actual nutriment.

We shall, therefore, reckon that—

| | |
|---|---|
| One acre of potatoes, or any other vegetable or root, will yield | 6,312 lbs. of dung. |
| „ Clover, in two mowings | 5,200 |
| „ Clover, in one mowing | 3,200 |
| „ Lucerne | 8,800 |
| „ Saintfoin | 4,400 |
| „ Vetches, manured | 4,400 |
| „ Ditto, not manured | 2,600 |

Independent of the additional weight which the straw will produce.

In 1805 I obtained sufficient dung from the consumption of 25 acres of green peas, with about 1,500 sheaves of straw as litter, and a small quantity of pine leaves, to manure 30 acres of autumnal corn that year.

With regard to the other part of the dung, namely, that which is produced by the straw, we have lately obtained some information which may be depended on. It is true that we have not hitherto wanted for data with regard to the quantity of sheaves which a certain extent of each kind of land will produce, or of the number of trusses of straw which ought to be derived from each species of grain; but yet we lacked any certain and invariable data with regard to the average weight of these sheaves or trusses. Every agriculturist and farmer who has gone beyond the confines of his own property, well knows that there are vast and almost incredible differences with regard to this matter; that, in some places, the sheaves only weigh 8lbs., while in others they weigh from 40lbs. to 50lbs. And the difference in the weight of the trusses is equally great, varying from 10lbs. to 40lbs. Hitherto, however, most persons have thought that they explained themselves sufficiently clear, when they stated the average amount of their crops according to their own system of proceeding.

It is generally considered that we may derive a tolerably exact notion from experience what amount of produce in corn may be expected from certain kinds of soil or systems of cultivation; and it is very true that where sufficient attention is paid to the subject, we may learn much in that manner.

But Commissioner General Meyer is the first person I ever knew who has systematically endeavoured to deduce the produce in straw from that of grain. No one, however, can be ignorant that there is an existing proportion between these two articles of produce. Every experienced farmer can calculate the amount of grain which one of his sheaves will yield; and after the first thrashing he is able to say whether these sheaves yield well or only middling, or very badly in that year. The variations which frequently occur on the same soil, and under the same kind of cultivation, are therefore exceptions to the general rule. If a favourable state of weather has caused the corn to shoot up quickly at first, to put forth a number of blades, and at the time of flowering the exceeding richness of the soil causes it to fall to the ground; or if bad weather, or the various diseases to which corn is subject, impede the development of the grain; or, lastly, if at harvest time the corn should be laid, then will the proportion of grain to straw be much less than usual. But if, on the other hand, a continuation of bad weather should stint the growth of the corn, or destroy a great number of the plants; or if mice or insects should thin the crop, and afterwards an interval of fine weather should intervene—which promotes the development of the ears, the fecundity of the flowers, and tends to mature and ripen the grain—then will the proportion of straw to that of the corn be much less than usual. But it is impossible to take all these exceptions into account while forming a general estimate of the results of rural economy.

According to most of the observations and experiments which I have heard of, or which have been communicated to me, the proportion of grain to straw varies,

| | | | |
|---|---|---|---|
| In rye, | from 38 | to 42 | in 100 |
| Wheat | .. 48 | .. 52 | .. 100 |
| Barley | .. 62 | .. 64 | .. 100 |
| Oats | .. 60 | .. 62 | .. 100 |

It is still more uncertain with regard to peas, for it is well known that there is no average with regard to the number of legumes that one plant will bear. The loss or diminution which this plant may sustain during the harvest or gathering, must likewise be taken into consideration. The Count Von Podewils has stated the proportion of grain to straw in this case to be as 5 to 21; but, if my opinion were asked, I should say we were much nearer the mark if we stated it to be as 35 to 100. The best mode of proceeding is to allow 2,000lbs. of straw for each manured acre of peas, because in this crop the product in straw is much less casual than in grain. The same may be said with regard to vetches.

If, then, a bushel of rye, of full measure, weighs 86lbs., and the average proportion of straw to grain be as 40:100, an acre of rye will yield a produce of—

| | | | | |
|---|---|---|---|---|
| 3 | bushels* | 645 lbs. of straw, | which in its turn yields | 1,290 lbs. of dung. |
| 4 | .. | 186 | .............................. | 1,720 |
| 5 | .. | 1,075 | .............................. | 2,150 |
| 6 | .. | 1,290 | .............................. | 2,580 |
| 7 | .. | 1,505 | .............................. | 3,010 |
| 8 | .. | 1,720 | .............................. | 3,440 |
| 9 | .. | 1,935 | .............................. | 3,870 |
| 10 | .. | 2,150 | .............................. | 4,300 |
| 11 | .. | 2,365 | .............................. | 4,730 |
| 12 | .. | 2,580 | .............................. | 5,160 |

If a bushel of wheat weighs 92lbs., and the proportion of the grain to the straw be as 50:100, an acre will yield a produce of—

---

* The measure here translated "bushels," is about 1½ of our measure of that name.

| 3 | bushels | 552 lbs. of straw, which, in its turn, yields | 1,104 lbs. of dung. |
|---|---|---|---|
| 4 | .. | 736 | 1,472 |
| 5 | .. | 920 | 1,840 |
| 6 | .. | 1,104 | 2,208 |
| 7 | .. | 1,288 | 2,576 |
| 8 | .. | 1,472 | 2,944 |
| 9 | .. | 1,656 | 3,312 |
| 10 | .. | 1,840 | 3,680 |
| 11 | .. | 2,024 | 4,048 |
| 12 | .. | 2,208 | 4,416 |

If a bushel of barley weighs 68lbs., and the proportion of the grain to the straw is as 63:100, an acre of land will yield in one crop—

| 3 | bushels | 324 lbs. of straw, which in its turn yields | 698 lbs. of dung. |
|---|---|---|---|
| 4 | .. | 432 | 864 |
| 5 | .. | 540 | 1,080 |
| 6 | .. | 648 | 1,296 |
| 7 | .. | 756 | 1,512 |
| 8 | .. | 864 | 1,728 |
| 9 | .. | 972 | 1,944 |
| 10 | .. | 1,080 | 2,160 |
| 11 | .. | 1,188 | 2,376 |
| 12 | .. | 1,296 | 2,592 |

If a bushel of oats weighs 52lbs., and the proportion of grain to straw is as 61:100, an acre of land will yield in one crop—

| 3 | bushels | 256 lbs. of straw, which will produce | 512 lbs. of dung. |
|---|---|---|---|
| 4 | .. | 341 | 682 |
| 5 | .. | 426 | 852 |
| 6 | .. | 512 | 1,024 |
| 7 | .. | 597 | 1,194 |
| 8 | .. | 688 | 1,366 |
| 9 | .. | 768 | 1,536 |
| 10 | .. | 853 | 1,706 |
| 11 | .. | 938 | 1,876 |
| 12 | .. | 1,024 | 2,048 |

In this estimate of the proportions in which dung may be obtained, it is always understood that the straw is employed for litter; or, should straw be scarce, those substances which are used instead shall be sufficiently plentiful, not only to receive and absorb all the different excrements, but likewise to enter into fermentation and become sufficiently decomposed without requiring any additional moisture; and further, that everything shall be so arranged that no portion of the urine shall be wasted or suffered to run off, and that the dung-steads shall be protected from the washing of heavy rains which might carry away some portions of component parts. This dung, composed of animal and vegetable substances, is supposed to be lifted at the period when the incipient fermentation has commenced, and when the straw has become softened without being decomposed; in a word, in that state in which experience teaches all practical agriculturists when it can be used with the greatest advantage. There is a great deal of difference between the weight of fresh dung and of that which has become completely decomposed, and in which the straw is quite dissolved. The amount of the humidity has already been indicated in a previous page.

In order to discover the quantity of dung produced by pasturing animals, that evacuated by a cow fed on excellent pasture land has been weighed, and it was found that, on an average, she produced 37 lbs. in a day and night; that is, 5,661 lbs. in five months, or one hundred and fifty-three days; the dung evacuated during the day was also weighed separately from that which was produced during the night, and it was found that the former amounted to from 21lbs. to 23lbs., and the latter to from 15lbs. to 15½lbs. That dung which is evacuated by cattle on permanent pasture land is lost for all agricultural purposes; but those farmers who use their fields alternately as pasture and arable land, derive some portion of benefit from it. Even then, however, it is not nearly so profitable as when mixed with the straw or litter in the stable or farm-yard, and properly collected. A great part of that evacuated in the fields is evaporated by the action of the sun and wind, or falls in the dust and is destroyed by insects; but the luxuriant tufts of grass which spring up wherever it falls, and the increased fertility of those parts of enclosed pastures on which the cattle lie down, or where they are milked, tends very satisfactorily to prove that it is not so completely wasted as some persons would have us to believe. In the rotations of crops with pasturage, in which it is usually the custom to leave the cattle in the field day and night, the dung thus made is already comprised in the ameliorating quality which we attributed to the repose or rest of the land.

But if the cattle which are depastured during the day are brought into the stable or farm-yard at night, the dung heap ought necessarily to be augmented by the addition of their excrements. We reckon this part of the dung which will be produced by a cow, plentifully fed, at 2,500lbs.; if she is not so well fed, as is usually the case with those that are pastured, it will amount to about 1,500lbs.; and the straw of which the litter is composed must here be reckoned separately.*

With respect to the dung proceeding from the fodder consumed by cattle, and the straw or other substances composing the litter, no difference is made, in general estimates, between the various kinds or breeds of cattle by which it has been produced. We shall, however, offer a few observations on this subject.

The amount of dung which will be produced from the same quantity of food by lean, ill-conditioned, weakly cattle, will neither be so great, so rich, or so fertilizing; nor does it contain so much animal matter as that which is produced by strong, healthy and well fed animals.

Sheep, if fed on the same quantity of provender, will produce dung which goes farther, but the action of which is not so durable. These animals, however, appear to be decidedly the most advantageous for the manuring of pasture land; the dung which they evacuate over the meadows is not only more equally diffused, but also amalgamates more freely with the soil, and acts more promptly on the vegetation. If the sheep are brought up from the pastures at night and confined in a paddock or sheep-fold, they will produce a proportionally larger quantity of manure than cattle, supposing that each species has been allowed the same extent of pasturage. This reason causes the meadow and pasture lands in England, where it is customary to leave the sheep out night and day, gradually to become ameliorated and improved, and to be capable of feeding an increased number of these animals every year; when these lands are broken or ploughed up, they are found to have acquired a much greater proportion of nutritive matter, than those on which cows have been fed; indeed, these latter usually decrease in fertility about the third or fourth year, particularly where the soil is of a dry, hot nature.

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* At the rate of 2 lbs. of dung to 1 lb. of straw.

When sheep are depastured it is usually reckoned that 1,200 will yield about the same degree of amelioration to an acre of land, as would be produced by one half of the quantity of stable manure generally allowed; 1,800 sheep are supposed to manure an acre and a half tolerably well, and 2,400 to manure it abundantly; so much so indeed, as to render it too rich for most kinds of grain. If ten sheep when pastured are regarded as equivalent to one cow, and if one cow produces 15lbs. of dung during the night, 180 cows will only produce 2,700lbs., and 240 cows 3,600lbs., which is not enough to manure one acre of land; but the effects and the nutritive properties of manure thus derived are much more permanent, and are retained much longer in the soil, than the dung of sheep.

In order to discover how far this estimate of the quantity of manure to be obtained, when founded on the consumption of fodder and straw, will agree with those which take for their basis the number of cattle, we will examine some of these latter which have been derived from experience, and drawn up from general averages, which may not, however, have been perfectly correct.

The table of the quantity of manure which may be derived from cattle (see *ante* p. 180,) has peculiar relation to the mode of feeding adopted for the estimates in the electoral market, and in the new market. According to this method, the following proportions are given to the different kinds of cattle:—

| | Straw from Winter Cereals. | Straw of Spring Cereals. | Hay. |
|---|---|---|---|
| For a large ox ............ | 3,600 lbs. | 1,680 lbs. | 1,650lbs. |
| .. Middle-sized ox...... | 3,000 | 1,400 | 1,375 |
| .. Small ox............ | 2,400 | 1,120 | 1,100 |
| .. Large cow .......... | 1,800 | 1,260 | 1,320 |
| .. Middle-sized cow .... | 1,500 | 1,050 | 1,100 |
| .. Horse which is always fed in the stable ........ | 4,800 | .. | 2,640 |

According to our system, the quantity of manure which would be derived from the above table, would be as follows:—

| | Quantity of Fodder and Straw. | Dung. | Extent of Land which could be manured at the rate of 10,000 lbs. per Acre. |
|---|---|---|---|
| For a large ox ............ | 6,930 lbs. | 13,860lbs | 1·38 lbs. |
| .. Middle-sized ox...... | 5,775 | 11,550 | 1·15 |
| .. Small ox............ | 4,620 | 9,240 | 0·92 |
| .. Large cow .......... | 4,380 | 8,760 | 1 |
| .. Middle-sized cow .... | 3,650 | 7,300 | 0·73 |
| .. Small cow .......... | 2,865 | 5,730 | 0·57 |
| .. Horse fed in the stable | 7,440 | 14,880 | 1·48 |

We do not here include the corn which the horse consumes, but place that against the time which he passes out of the stable.

If, then, we take a large, or a middle sized, or a small ox, according as straw is plentiful or scarce in the country, and if we further admit that on a cold soil from 20 to 22 metzen has been sown, and on a warm dry soil from 18 to 19; and, finally, if we allow a somewhat larger quantity of dung, about 12,000lbs., to the former, and a smaller quantity, as 9,000lbs., to the latter, it will be easy to apply the data contained in the above table to particular fields or pieces of ground, and to the quantity of fodder which is necessary for them. But if we should wish to calculate the general average of cattle and of fodder as it is stated in this table, we shall find that one beast will produce dung enough to manure $1\frac{19}{60}$ acres. In the instructions and rules laid down for the estimate of the income proceeding from corn in the kingdom of Prussia, the following were taken as their basis from being most conformable to general experience:—

They calculate that the produce in straw of an annual sowing will, for a fat animal, be from 1¼ to 2½ acres of land of the first and second class, from 2½ to 3½ of land of the third class, and from 4 to 5 acres of land of the fourth class. But it would seem, from reference to all other data, that we are to understand by the term "large" or "great beast," small horses, oxen, and cows when pastured. If, therefore, we admit that the product of the first and second class land is nine bushels per acre, we shall find that we obtain

| | |
|---|---|
| From 1¼ acres of rye, calculated at 1,935 lbs. per acre, a produce of ........................................ | 2,418 lbs. of straw. |
| From one quarter of an acre of barley, at 972 lbs. per acre | 1,215 |
| To which must be added the hay ........................ | 1,320 |
| | 4,953 lbs. |

Which will make altogether about 9,906 lbs. of dung.

But if we take three acres at seven bushels of produce for the third class;

| | |
|---|---|
| There will be on one and a-half acres of autumnal corn | 225 lbs. of straw. |
| There will be on one and a-half acres of spring corn .. | 1,134 |
| To which must be added the hay .................... | 1,320 |
| | 4,711 lbs. |

Which will produce an amount of dung equal to 9,422 lbs.

According to the data on which this instruction is founded, each beast produces ten loads of manure for four horses, that is, generally, at most ten quintals to each horse; fifteen such loads are usually considered to be requisite for every acre, if we would have the ground retain the effect of the manure during the nine years' rotation. Thus, one beast and a half may be said to manure an acre of land.

The more carefully we compare a number of data deduced with the utmost exactitude from comprehensive averages, and relating to the produce in dung, with the fundamental principles which we have here detailed, the more shall we feel convinced that they perfectly agree with one another, and that an estimate of the quantity of dung which it is possible to obtain may be derived with much greater precision from comparison and reference to the amount of straw and fodder consumed, than it could be by any other means; and we shall, therefore, henceforward be guided by it in all our agricultural calculations and estimates.

The data with regard to the necessary quantities of fodder, are as numerous as they are various. It is sometimes scarcely possible to believe that they can refer to the same animals. But then, how great is the difference between a small, lean, ill-conditioned beast, that picks up a scanty living on arid fallows, in the woods, or on open commons, and another that is plentifully fed in the stable or on rich and fertile pastures! Some oxen do not yield above 200 lbs. of meat when slaughtered, while others yield 2,000 lbs. It would be absurd to pretend that these different kinds of animals receive the same kind or quality of food, or to expect that they will yield the same quantity of dung.

We have already stated the quantity of straw and fodder which, in most agricultural estimates, is generally supposed necessary for the winter feeding of cattle of various kinds, breeds, and size; it only remains for us to consider the account given by some of the authors who have treated on this subject.

De Bénékendorf allows one bushel, or 8 lbs. per day, of chopped straw of spring corn for every draught ox; and three-quarters of a bushel for a cow. It is his opinion that a piece of land, sown with three bushels of barley or oats, will yield 319 bushels of chopped straw; and that, as the duration of the winter-feeding is 165 days, two oxen or cows may be kept on the produce of one sowing of three bushels of spring corn; he also thinks that the straw of rye and peas ought to be devoted entirely to sheep; that the number of cattle ought to be regulated by the quantity of straw, since the summer pasturage might be replaced by green clover given in the stable, and that by means of crops of roots it might be possible to do without hay.

Independent of that circumstance, a draught ox, according to him, requires 12lbs. of hay per day, from the first of January to the first of June; a milch cow, 13 cwts. of hay in a year, besides grains, corn, and *soupe*,* or if she is fed on hay alone, 18 cwts.: young or barren beasts require 4 cwts., if they are allowed other provender besides; and otherwise 11 cwts.

According to Karbe, a draught ox ought to receive a daily provender of

18 lbs. of chopped straw, 2 lbs. of straw as litter; in all, 4,800 lbs.
4 metzen of roots, or 60 bushels yearly.

during the whole of the 240 days of winter.

If roots and vegetables are scarce, or nearly all spent, 30 lbs. per day of corn, chaff, hay, chopped straw, and of litter may be substituted. Thus an addition of perhaps 10 lbs. of hay, instead of roots, where the latter are altogether taken away, will amount to 2,400 lbs. per year.

A milch cow ought to be allowed 18 lbs. of straw and hay for food per day during the 190 days of winter, and 2 lbs. of litter = 3,800 lbs. per year; and likewise 4 metzen of vegetables or roots per day, or 50 bushels per year. During the 175 days of summer, a pasturage of 3 acres of clover and grass, and 2 lbs. of litter every night, or 350 lbs. per year.

An ox for fattening, ought to receive in each of the 112 days, which are usually allowed for that purpose—

| | |
|---|---|
| 10 lbs. of chopped straw and ........<br>2 lbs. of litter .................... | 1,344 lbs. straw. |
| 8 lbs. of hay ...................... | 896 lbs. |
| 8 or 9 metzen of vegetables or roots .. | 60 bushels. |

In my edition of "Bergen's Anleitung zur Viehzucht," I have given an account of the quantity of fodder consumed by my cows in the course of a year, at a period when all my cattle were of the heaviest breeds. It amounted to the following per head:—

---

* A kind of pottage composed of grains or of cooked potatoes, and sometimes also of water mingled with meal, and poured over the chopped straw.

| | | |
|---|---|---|
| White cabbages........ | 4,890 lbs. | 815 lbs. reduced to hay. |
| Potatoes.............. | 3,900 | 1,950 |
| Radishes.............. | 1,830 | 343 |
| Carrots .............. | 1,230 | 462 |
| Green clover .......... | 14,080 | 3,129 |
| Hay ................ | .. | 1,660 |
| Straw as fodder ...... | .. | 2,312 |
| Ditto, as litter ........ | .. | 3,650 |
| | | 14,321 lbs. |

Which produced 32,938 lbs. of dung, or very nearly sixteen loads of 2,000 lbs. each.

With such an amount of fodder, the cattle certainly ought to be completely satiated, but they did not at any time suffer from indigestion. In proof of this I shall state the daily quantity of milk yielded by each of my dairy cows, which amounted on an average to 10 quarts of Hanoverian, or 8 quarts of Berlin measure; making 3,650 Hanoverian or 2,920 Berlin quarts per year.

These variations in the data may suffice to prove that horned cattle require little for their actual subsistence, and also that they can consume a great quantity. On the whole, an abundant supply of food is, to a certain degree, far more profitable in the end, than any great saving or economy on this head ever can be. I have, however, ascertained, by long experience, that large-sized beasts can only be rendered profitable by being very abundantly fed. In order to establish the average quantity of food and straw on which a moderate-sized ox or cow can be most advantageously kept, I shall admit that a good milch cow or draught ox, when fed in the stall, will annually consume

| | |
|---|---|
| In straw, for fodder and for litter ............................ | 4,500 lbs. |
| In hay, the various kinds of green fodder being also reduced to it . | 4,500 lbs. |

But when these beasts are pastured during the day, they have an equivalent to 4,000 lbs. of straw, and also to the quantity of roots which, if reduced to hay, would amount to 2,800 lbs.; by these means, in the former case, 18,000 lbs., or nine loads of dung will be obtained, and in the latter, 13,600 lbs., or six loads and three-quarters.

A draught horse, when fed in the stable, requires

7,500 lbs. of gross fodder, one-third of which should be hay and two-thirds straw, besides a sufficiency of corn.

We shall find a still greater number of variations in the accounts of the winter feeding required by sheep. In "Den Tax Prinzipien," (the principles of estimation) we find the amount of fodder necessary for a hundred sheep which were turned out at intervals during the winter, stated at 4,950lbs.; and that requisite for the same flock when turned out more frequently, at 3,850lbs. of hay. On the other hand a flock of sheep of an improved breed consumed:—

| | Dry clover. | Straw and Peas. |
|---|---|---|
| Per 100 of Ewes ............ | 16,600 lbs. | 5,500 lbs. |
| .. Yearlings ........ | 22,000 | .. |
| .. Lambs and lamkins | 5,500 | 16,600 |
| .. Wethers ........ | .. | 22,000 |
| | 44,180 lbs. | 44,100 lbs. |

Thus, on an average per 100 sheep, 11,025 lbs. dry clover, and 11,025 lbs. straw and peas, besides straw for litter.

In the sheep-fold of Kunersdorf containing four hundred and sixty-six sheep, in 1804, the following amount of produce was consumed:—

| | | |
|---|---|---|
| Hay ........................ | 1,200 | cwts. |
| Horse beans .................. | 108 | bushels. |
| Peas ........................ | 46 | bushels. |
| Oats........................ | 7½ | bushels. |
| Rape cake .................. | 300 | pieces. |

Which is, indeed, an astonishing difference.

In order to determine what extent of pasturage is necessary for a cow, I shall take as a basis a table contained in Commissioner General Meyer's work, and in which all the principal items which relate to this subject are carefully defined and distinguished.

I must, however, observe in the first place that this table has reference to pasturages formed on fields during their period of repose, and to a small breed of cows, such as are found in the Mecklenburgh dairies.

The table relates to the meadow pastures both in spring and in autumn. In those cases where, from the fields being laid down for pastures all the year round, three acres are sufficient for one beast, a cow is supposed to require:—

| | Acres. | Square perches. |
|---|---|---|
| From the beginning of August to the 12th of May | 9 | 40 |
| From the middle of August to the 12th of May.. | 11 | 40 |
| ——————— to the 1st of May .............. | 10 | 60 |
| ——————— of September to the 12th of May. | 15 | .. |
| From St. Michael's to the 12th May ........... | 25 | 36 |
| From St. Michael's to the 1st May............. | 36 | 24 |
| From St. Martin's to the 1st May............. | 116 | 80 |
| From St. Martin's to the 12th May............ | 48 | 100 |

The difference between the first and the twelfth of May is indeed striking, but it is in accordance with the nature of things; because in these eleven days the vegetation is considerably more active, which accounts for the fact that the pasturing of cattle at this period is very injurious to the meadows. If the animals were continued on pasture to the 24th or to the end of May, this difference would become still more evident.

I shall also refer my readers to the same work for a table estimating the pasturage found in forests. The profit which may be derived from them, and the influence which is exercised over it by the kind and size of the trees with which these forests are filled, will all be found very accurately defined and distinguished there.

The Calenberg acre, according to which Meyer forms his calculations, is three square perches, and three quarters larger than the Berlin acre. It contains a hundred and twenty perches of sixteen feet each, but these latter are shorter than the Rhenish feet.

A great number of agriculturists are of opinion that ten sheep will consume as much winter-fodder or pasture as one cow; but this depends, in a great measure, on the nature of the pasture, for there are some kinds of mountain herbage, a certain extent of which, though quite sufficient for the keep of ten sheep, will not support one cow; while, on the contrary, there are others perfectly adapted for pasturing cattle, and are by no means suitable or profitable for sheep. In fact, the number of animals which can be kept on a certain extent of pasture depends, in a great measure, on the breed of the animals, and the purpose for which they are designed. In those places where improved breeds of sheep are kept chiefly, if not entirely, for the quantity of wool which they may be made to produce, an extent of pasture which will generally feed a cow, will barely suffice for seven sheep; while, on the other hand, an extent of pasture sufficient for fifteen sheep will afford a very poor and meagre feeding for a cow belonging to one of the large breeds. But as these differences can only be duly appreciated in certain definite localities, and by reference to the lands or the animals in question, we shall not stop to include them in our average estimates, but confine ourselves to the original one.

### THE VARIOUS SYSTEMS OF CULTIVATION.

One of the most essential conditions attending every rotation of crops is that the proportion of labour and manure shall be suitable and proportionate to the extent and quality of the soil.

The well known necessity of animal manures in the cultivation of every species of vegetable products, and particularly of corn, has led all nations and all ages to consider that arable culture and grazing ought to be united, in order that each may be made to produce all the advantages which may be derived from them. There is but one opinion on this subject; but there are many disputes on the subject of their reciprocal relation to each other, and on the determination of the quantity of land which ought to be devoted to each; and particularly on the relative proportion which they ought to bear to one another, in order that the greatest possible amount of animal and vegetable products may be derived from their union.

These systems of cultivation may be divided into two classes. In agricultural undertakings regulated by the first of these principles, the chief part of the land is devoted exclusively to the cultivation of corn or of other vegetable products, which are intended solely for the consumption of the human race; and a very small part only to the raising of food for the grazing of cattle. The meadows and fields are separated from each other; one portion of the latter is mown, and on the other portion cattle are pastured.

In the second class, the same piece of land is made to produce alternately grass or vegetables for fodder and corn; the proportion, quantity, species, &c., of the different crops, and the frequency of their repetition, or the order in which they succeed each other, being regulated by the soil, the climate, and the nature of the locality. The first class is generally designated *cultivation of grain or corn*, and the second *alternate husbandry*. We shall presently point out the various subdivisions of these two classes, and the deviations from the general rule.

These two classes are now frequently combined; for it has latterly been deemed expedient to introduce the cultivation of plants destined for fodder into those rotations which were formerly exclusively devoted to the cultivation of corn.

### *Class* 1. *The Cultivation of Corn.*

Fields submitted to this system are appropriated solely to the cultivation of crops of various kinds of corn. We shall henceforth designate under this title the cultivation of all products destined chiefly for the wants and subsistence of mankind, and which consequently find a sure and ready sale. Where this system of cultivation is pursued, it will be necessary to have pasture grounds and natural and artificial meadows on those portions of land set apart for the purpose of feeding cattle. If these are sufficiently extensive to maintain the number of cattle which it will be necessary to keep in order to provide the requisite quantity of manure for the soil; and if these portions of land cannot be rendered more advantageous to the whole by any other means, then it may be admitted that this system attains its end, viz., that *of yielding the utmost possible amount of net produce*, and no objection can be offered against it. There certainly are instances of this case existing, but they are seldom met with, and are far more rare than most of the advocates and defenders of this system appear to believe.

This system likewise receives the names of the three, four, and five-course shift, according to the number of years which each course occupies, or which intervene between each manured fallowing. There are some rotations belonging to this class which extend to six and even to nine years; but these, as we shall presently see, can only be regarded as repetitions of the triennial rotation.

This latter is the one most frequently used, and we shall therefore begin with it; and having examined it in its primitive excellence, shall proceed to notice the additions and improvements to which it has been submitted. Afterwards we shall treat of the other rotations.

During the time of the Romans, the triennial rotation of crops, as it in all probability existed and was practised in every part of Europe except in Italy itself, where it does not seem to have been introduced until the 14th century by the Barberini, whence it derived its name, consisted in,

1. A naked fallow, with repeated ploughings during summer.
2. Crop of autumnal corn.
3. Crop of spring corn.

The fallow ought always to be manured, and this invariably used to be the case when the proportion of meadows and pasture ground to arable land was much greater than at present. At the present day, however, the fallows are only regularly manured in a very few fertile countries, or in districts where there is a great deal of rich meadow land, or perhaps where the union of stall feeding and the cultivation of plants for fodder with this system renders the procuring of manure a less difficult task. In general only every second and sometimes only every third fallow is manured, and thus the fields are only ameliorated once in six or nine years. Many farmers who have broken up their meadow and pasture ground for the purpose of converting it into arable land, have found themselves so much reduced by the diminution of fodder and straw as to be unable to manure even a ninth part of their fields properly; and have frequently been compelled to leave a great portion of their arable land wholly untouched, or at most able only to give it a very slight covering of manure in order to reserve the quantity necessary for those fields which are either better in quality or nearer to the buildings. This neglected part is termed exterior field or out-field land, or, according as it yields a crop of rye in three, six, or nine years, it receives the appellation of three, six, or nine year rye-land.

Where the soil is of a fertile clayey nature, and if properly cultivated, it might be classed among wheat land; and if *spelt* is also raised upon it, it is called *spelt land.*

If the land will produce ten bushels of spring and ten bushels of autumnal corn per acre, and two thousand pounds of straw from the former and one thousand from the latter, when cultivated according to the triennial succession of crops, six thousand pounds of manure, or three loads of twenty quintals each, will be obtained according to the principles stated in page 178; and as at least five such loads are requisite for a three years' manuring, there will yet be wanting two loads or four thousand pounds of manure, and these must be procured by means of hay. A supplement of two thousand pounds of this last mentioned description of fodder will therefore be requisite, or the produce of an acre and a quarter of meadow land of medium quality. Every agricultural establishment which has attained the condition to be able to furnish this quantity of manure, and which, consequently, possesses an acre and a quarter of meadow land besides the quantity of pasture land necessary for keeping the cattle in working condition during the summer, for every three acres of arable land, may support this rotation of crops without weakening itself in the slightest degree; and as, in addition to the manures above mentioned, there is also a quantity which the cattle, and more particularly the sheep, yield during the night, it follows that the fertility of the soil must be continually on the increase; so that, eventually, those kinds of grain which find the readiest sale, and yield the greatest profit, may be advantageously cultivated.

When the soil is manured only once in six years, and the produce of the spring and autumnal corn on land of medium quality amounts to seven bushels when the fallow has been manured, and to four bushels and a half when it has not received any assistance—and the produce of six years may consequently be estimated at eleven bushels and a half of autumnal grain, and as many more of spring grain, together with 2,480lbs. of straw from the former and 1,150lbs. from the latter, making in all 3,630lbs., which will yield 7,260lbs., or $3\frac{5}{8}$ loads of manure, while the land requires at least 5 loads of manure—2,740lbs. will, therefore, still be wanting; to produce which it will be necessary to have 1,370lbs. of hay. It appears, then, that the triennial rotation can be kept up and made to yield the average quantity of produce which may be expected from it, if there are seven acres of meadow land, besides an adequate extent of pasturage to every six acres of arable land. And that, by means of these resources, and of the manure produced by the cattle, and especially by the sheep at pasture during the night, the land can be preserved from that exhaustion with which it would otherwise be threatened.

The small produce of those rotations in which the manuring takes place only once in nine years, is well known to every person, and has been already mentioned in the sections above cited.

We have supposed that the establishments in which the triennial rotation of crops is adopted, possess a sufficient quantity of pasture land; but, in reality, this is seldom the case. If, where this system is adopted, a sufficient number of cattle are kept to convert into manure the whole of the hay and straw which can be allowed them, there ought to be as many large cattle as there are acres of land to be annually manured. And it is necessary to assign from three to five acres of open pasture land, according to the quality, and from ten to fifteen acres of forest-pasture to each beast, if we would keep them in condition, and prevent their annual return of profit from being far below what it ought to be.

We may, however, deduct the pasturage which is allowed for the draught cattle from this calculation, because these animals ought, properly speaking, to be fed in the stable. Now, as it seldom happens that the disposable quantity of pasture-ground is so great as here required, it not unfrequently happens that, in establishments in which the triennial rotation is adopted, the horned cattle yield a very scanty return, even when every necessary care is bestowed upon them, and where they have been well fed throughout the winter. The profit yielded by cattle is therefore almost exclusively derived from the sheep, and in such establishments even these animals are seldom supplied with sufficiently ample pasturage to enable them to yield that amount which might otherwise be expected from them. It is often necessary, as well for the sake of these animals as from want of pasturage, to defer the fallowing until the middle of the summer; a course of proceeding which is totally at variance with the essential conditions of this rotation, and which, when applied to argillaceous soils, diminishes the quantity both of the grain and of the straw produced.

The name of Schubart will be enrolled in the annals of Germany in indelible characters as one of the benefactors of the human race; although it must be admitted that he, in common with other mortals, was unable to steer wholly clear of error. He laboured with indefatigable zeal to procure the abolition of the practice of letting the land lie fallow, and also of the rights of pasturage over fields as well as that of pathway; but it was not until long after his death, and after great hesitation on the part of the governments, that his wishes at length met with attention, and were adopted by Maximilian Joseph, king of Bavaria, and other princes of Germany, who, like enlightened and beneficent fathers of their people, sacrificed to them those usages which had been practised until that time for the imposition of burdensome taxes and exactions, the origin of which were mostly very equivocal.

This system of Schoubart's revived the long-agitated dispute respecting the necessity or abolition of fallows, in all its original vigour, and this question appeared for some time to be more important than any other; reams of paper were consumed in the discussion of it, but no satisfactory result was attained.

As this question relates chiefly to the triennial rotation, we shall take the present opportunity of discussing it.

The principal misapprehensions, errors and disputes on this point have arisen from no precise and definite meaning having been attached to the term *fallow*. This word originally signified the state of a portion of land which, during the summer, or, what was better still, during the whole year, was turned up and carefully broken and divided by means of the plough or spade, in order to prepare it, as perfectly as possible, for the reception of the ensuing crops.

Most of the Roman writers on agriculture recommended this operation, and prescribed it as being necessary under certain circumstances; and many of them have given particular names to each of the processes which it includes. Thus they designate that act which we term breaking up by the Latin word *frangere*, the second ploughing by the word *vertere*, the third by *infringere*, the fourth by *revertere*, the fifth by *refringere*, the sixth, or that immediately before the sowing, by *lirare;* just as we have our particular terms by which to distinguish each of these operations.

But some persons have attached a widely different signification to the term "*fallow.*" As the fields were, either from negligence, from want of pasturage, or from a defective system of practice, and in total opposition to the aim and object of fallows, frequently suffered to remain unploughed until June, and sometimes even until August, and, nevertheless, were called fallow-fields, this word came, by degrees, to be used in a corrupt sense, and to be applied to land in a state of repose, and this introduced a misunderstanding and misconception into the discussion.

It is, therefore, necessary to restore to this word the meaning which properly belongs to it. Thus, to put in fallow, is to prepare land for the ensuing crop by repeated ploughings performed during the summer, without seeking to obtain any produce whatever from it during that year. A field cannot therefore be said to be *fallow* until it has been ploughed once, and until, in short, it has been fallowed; for up to that time it can only be termed a field in a *state of repose.* When cattle are fed on it, the pasturage thus obtained is designated a pasture on a field in state of repose.

The utility of ploughing fallow ground cannot possibly be overlooked or denied; and the more tenacious or argillaceous the soil may be, the greater is the advantage which will be derived from it.

A simple ploughing in spring or autumn certainly will turn up and break the surface of the land, but it will not divide it sufficiently to break the clods and reduce them to loose earth. The soil when clodded together soon becomes hardened into compact masses, when it is covered without being broken; it even preserves the impression made upon it by the plough; and when the ploughing has been performed while the ground was wet, the divided portions exposed to the heat of the sun become as hard as a tile. Land when suffered to acquire this state is highly unproductive, because the greater part of the plants having fibrous roots are unable to penetrate these clods, and, consequently, are forced to turn round them, and the power of vegetation contained in the portion of ground which they occupy is therefore wholly lost. The soil might as well be composed for the most part of stones as of mould thus conglomerated. There is scarcely any means by which these clods can be effectually broken, except by continued fallowing during the whole of the year, the effect of which is to bring them all successively to the surface, where they may be exposed to the action of the atmosphere; and having imbibed moisture and become softened, they may be broken by the harrow and other implements. If this process can be continued from the end of summer to the seed time of the following autumn, and care be taken that each operation shall be performed when the soil possesses the proper degree of humidity, the field will become transformed into an homogeneous light loose powder, and all the nutritive and fertilizing particles which it may contain will be brought into action; thus, we frequently see fields which were, to all appearance, exhausted, become exceedingly fertile after having been carefully fallowed, even though they have not received any additional supply of manure.

The second benefit which fallowing confers upon the land is the destruction of noxious weeds which have multiplied in it, either from their seeds or by the roots. These weeds being frequently torn up by the harrow, crushed by the roller, exposed to the action of the air, and to the influence of the sun, ultimately perish, and enrich the soil by rotting upon it. As for the seeds of these weeds, they are brought to the surface by the action of the plough, detached from the clods which frequently contain innumerable quantities of them, and placed in a position which facilitates their germination; and, at the commencement of their vegetation, the plants which have sprung from them are torn up and destroyed by the action of the plough or harrow, and contribute by their decomposition to the fertility of the soil. The fallow ground is thus freed from those quantities of weeds which multiply almost to infinity amongst the corn; that is to say, if the land has been broken up at an early period, and if sufficient care has been bestowed on the ploughing and tillage, for the clearing of the soil from weeds depends entirely on the nicety with which these operations are performed.

In the third place, experience has taught us, and recent discoveries in chemistry and natural philosophy have tended to prove the fact, that even the richest land ought to be occasionally exposed to the influence of the air, if we would have it become and remain fertile; and that it derives certain particles of matter from the atmosphere which must be combined with it in order to be transmuted into nourishment for plants. When the surface of the soil is hardened, it is as incapable of absorbing these particles of matter as the clods themselves. It is only where the soil is loose and divided that the atmospheric air can penetrate, and come in contact with all its component parts, and produce its fertilizing influence upon them. This absorption of gaseous matters takes place only at a very high degree of temperature, and appears to be most active during the warm weather of spring. The operation of fallowing is the mode best calculated to ensure to a soil all those advantages which are derived from being frequently turned up, and from its surface being often changed, and exposed to the action of the atmosphere and of light.*

Lastly, it is by fallowing that the most complete mixture and incorporation of the various constituent parts of the soil and of the manure which has been added, can be obtained. In order that the latter may produce the full effect, it ought to be brought in contact with, and to be able to fertilize every particle of the soil; indeed, all husbandmen are aware that the effect of manure which is placed in the ground in lumps, is very trifling. There is no method by which the proper degree of admixture can be so completely effected as by fallowing; particularly when the land is also ploughed and turned up several times after the dung has been placed upon it.

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* The description here given by the author, of the process of fallowing land when properly executed, shows that he fully comprehended the meaning of the word in the proper sense, and he very justly reprobates the imperfect performance as being the main cause of having brought a discredit on the process. The concluding observation on the mixture and incorporation of the constituent parts of soils and manures, as forming one great advantage derived from fallowing, is highly scientific, practical, and most valuable, and of which the benefits are yet forthcoming; for the very best and most improved practice of our day has not yet reached that point, though clearly demonstrated by observation and experience, and also by natural and chemical science. Clods of soil and lumps of manure, as the author very judiciously remarks, exert little influence on each other; the reciprocal action of affinity is not produced from want of comminution and commixture, so as to expose to mutual influence the greatest possible surface of particles. Delta grounds and alluvial soils, and experience in every cursory trial, fully confirm the truth and value of the theory.

To all these recommendations it must be added, that fallowing allows the ploughing to be executed with a smaller number of cattle; because the preparation of the soil and the carrying of the manure for the fallows can be performed at a time when there is a respite from all other ploughing operations. In large agricultural establishments which do not possess an extra number of teams, it is frequently a difficult matter to get the land ready for all the sowings unless it has been prepared by fallowing; and the sowings are not unfrequently retarded, to the manifest detriment of the crops.

Thus, notwithstanding the expenses attendant on fallowing, and the temporary cessation of all return or profit occasioned by it, which is very perceptible, especially where the land is of a superior quality, the advantages that result from it are so great, that without the possession of some extraordinary means of tillage, it is impossible to dispense with it in any of those rotations in which the corn harvests frequently succeed each other.

Where attempts have been made to dispense with fallows on the well-manured lands in the neighbourhood of towns, the ground has become filled with weeds, and notwithstanding the favourable appearance of the corn during spring, it yielded a very scanty crop of grain; so great indeed were the inconveniences resulting from this system of cultivation, that one fallowing was insufficient for correcting the defects which the soil had contracted, and it was often found necessary to lay it down to grass for some years, or to expend a great quantity of manure upon it, and then devote it to the raising of crops of various kinds of fodder for cattle, until, after receiving certain preparatory tillage, it can be again sown with grain.

The only thing which will enable us to dispense with fallows, and with those periods of repose which we lately mentioned, is an exceedingly careful tillage, such, for example, as that which the Belgians bestow upon their land, by arranging and dividing the surface of it in narrow beds or strips, after having, in the first place, pulverised it by the action of the plough, the harrow, the roller, and other agricultural instruments; by sowing the tops of the ridges only, and leaving the sides exposed to the influence of the atmosphere, and by the cultivation of various kinds of plants, and by weeding and hoeing them with the hand, which, although not a general practice in triennial rotations, is very frequently introduced, and often with very material benefit.

It is not so necessary to repeat the operation of fallowing every third year, as was formerly supposed; the land may often be maintained in better condition by being employed in the cultivation of vegetables destined for the feeding of cattle, which will be the means of producing a greater quantity of manure than if it were fallowed every third year. But this mode of proceeding requires very great care and attention, more extensive power and facilities at command for working the land, and a period of time of sufficient length between the harvest and seed-time to allow a very careful tillage being bestowed on the soil. Fallow crops are certainly far more efficacious than naked fallows, when, as is the case in some districts, these latter are not commenced until after the middle of the summer. Hence the late barley, which frequently is not sown until the middle of June, is to be recommended for such rotations, notwithstanding the uncertainty of the success. If land which is to be completely fallowed is very carefully ploughed at least four times during warm and dry weather, it ought to continue clean and fertile, and free from weeds, and the farmer has a right to expect crops of clover, leguminous plants, or other fallow crops, on the next fallowing, if not on the two succeeding fallowings.

The considerations just mentioned have given rise to the compound triennial rotations, or, more properly speaking, to the six, nine, and twelve year rotations, which many farmers and agriculturists are in the regular habit of pursuing. These systems comprise the following courses of crops:—

1. Fallow. 2. Autumnal corn. 3. Spring corn. 4. Peas and clover. 5. Autumnal corn. 6. Spring corn.

Or: 1. Fallow. 2. Autumnal corn. 3. Spring corn. 4. Clover. 5. Autumnal corn. 6. Spring corn. 7. Peas. 8. Autumnal corn. 9. Spring corn.

Or: 1. Fallow. 2. Autumnal corn. 3. Spring corn. 4. Clover. 5. Autumnal corn. 6. Spring corn. 7. Fallow. 8. Autumnal corn. 9. Spring corn. 10. Peas. 11. Autumnal corn. 12. Spring corn.

It is seldom, however, that we meet with intelligent and observing agriculturists who strictly adhere to these rotations; they either sow their land with clover, or reserve it for leguminous crops, or suffer it to lie fallow, according to the state of it at the time the barley is sown, or according as it is more or less light or free from weeds. They choose the clearest part of the land for clover and peas, and do not restrict themselves to a systematic course of crops, but are guided by circumstances, making it a rule to sow clover in the same place only once in nine years, experience having proved that it does not succeed if repeated oftener. When it happens, after having sown leguminous plants, either from unfavourable weather or from their having over-rated the fertility of the soil, they do not obtain a sufficiently abundant crop to cover the ground with its leaves, they either have it eaten off the ground while in a green state by cattle, or bury it with the plough and lay down the land for a naked fallow.

Although the pure triennial rotation leaves one-third, or very nearly that proportion of the cultivated ground unemployed, it has, nevertheless, been frequently represented as the best, and, indeed, as the only good system of cultivation that can exist, and for the following reasons:—

1. From the excellence of this system being proved by its universality and antiquity; it being incredible that a defective system should have received the approval of all nations and all ages, and have been able to extend and maintain its ground so generally.

2. From no system, hitherto known or discovered, pro-

ducing so great an amount of grain. From corn being the principal food of man, the most necessary kind of produce, and, consequently, that for which there is the greatest demand, and the production of which is most profitably and equally repaid. From the fact of this system yielding a smaller amount of animal produce being in itself a strong proof of the great utility, since land will yield three times as much nourishment for the human species in vegetable produce as in animal food. From being thus equally advantageous and profitable to society, to the state, and to the farmer.

3. From labour being more equally divided in this system than in any other. From its allowing more time between the spring and autumnal sowings for tilling the fallow ground and carting the manure. From its being thus possible to get the land ready early enough for the sowing of the autumnal corn, the crop of which is the richest and the most important; and, consequently, from being possible to work out this system with a smaller number of teams.

4. From all the agricultural operations appertaining to this system being simple and requiring little skill; and from being, consequently, possible to execute them by means of ordinary labourers. From their likewise requiring the most simple instruments, and those which are best known and in most common use.

5. From this system being founded on an already established division of land; from the fact that all the laws, regulations, and customs relating to agriculture, and all its external privileges and liabilities being closely linked with this system, which cannot in itself be altered without annihilating all these institutions.

But all these considerations vanish when tested by the following facts:—The antiquity and universality of this system admits of no dispute. It has come down to us from the Romans, who introduced it into their remotest provinces, and especially into those from which they derived their corn; but in the environs of Rome and in some of the most populous districts of Italy, they adopted a similar system of tillage to that used in gardens, and an alternate rotation which was much more advantageous. The Roman ecclesiastics, by whom most of the arts and sciences, and agriculture in particular, was disseminated among the barbarous nations, pointed out to them this system as being the most advantageous. These people still possessed a superabundance of land, although it was no longer possible to till those uncultivated and undivided lands, or keep and graze their flocks over them as they had previously done.

In the capitular of Charlemagne, *de villis et curtis Imperatoris*, the triennial division is positively dictated to his officers and stewards. It is not, therefore, at all astonishing that, in an age when authority predominated over every other consideration, and the understanding ventured not to oppose, but blindly submitted to every regal or positive enactment, that the triennial rotation should have become so prevalent throughout Christendom, and that laws and ordinances, whether relating to property or to agricultural affairs, or to rural policy, should have been based upon it.

It is, likewise, natural enough that no change should have been made in this system during the dark and troubled times which followed, when agriculture was entirely carried on by a class of peasantry, men buried in the depths of slavery and ignorance, or under the inspection of the lowest grade of freemen. Those institutions and practices which custom had sanctioned swayed the arts and sciences for a considerable lapse of time with irresistible power, and any one who ventured to express the slightest doubt of their conformity with the laws of reason was regarded as little short of a heretic. It is only of late years that anything like discussion on the virtues or defects of this system has arisen; and it was only on some portions of land in the Netherlands, Holstein, and in some counties in England, where any other system of cultivation had been adopted. This observation is sufficient to show how slight is the support which the triennial system derives from antiquity and universality.

Changes in the succession of crops in the triennial rotation have, however, already been frequently made with the general consent of proprietors, even of portions of land on which a common right of pasturage was exercised. I know several villages in which the fields are thus cultivated:—1. Fallow. 2. Barley. 3. Peas. 4. Rye. 5. Oats. 6. Rye. And then the land is fallowed again; or it is manured for the following succession:—1. Barley. 2. Rye. 3. Fallow. 4. Rye. 5. Peas. 6. Barley. 7. Rye. 8. Oats. 9. Fallow.

Where the soil is very strong, it is scarcely considered safe to sow wheat upon manured fallow ground, from fear of the crop falling down. It is, therefore, more usual to sow barley, which, according to the general opinion in these parts, is less exposed to this accident than wheat. But against all these reasons the triennial system still maintains its ground, and has its supporters.

In some places the quadrennial system of cultivation has already been introduced and practised for many years on the common or parish lands. The following is then the order or succession of crops after the fallowing:—1. Autumnal corn. 2. Spring corn. 3. Autumnal and spring corn or peas, and then another fallow. This last selection is as contrary to all the rules of agriculture as can possibly be imagined. Peas, when properly cultivated, are an excellent preparation for a corn crop; and, after bearing them, there is not the slightest occasion for the land to lie fallow.

Many landowners have adopted on their own farms and prescribed to their tenants a sort of quadrennial rotation, from which they anticipate very great advantages. This system, which appears to me to be founded on a misconception of the English quadrennial alternate rotation, comprises, first, a year of clover crops, independent of the one allowed for the fallow crops; and then crops of corn in succession; which are to be followed by clover on the fourth year. The clover, as might have been expected, was much less successful under this rotation than under the triennial rotation. On lands thus divided, it is now customary to raise three successive crops of corn, and then to let the ground lie fallow. I know but one single instance of an estate on which, for the last five-and-twenty years, the English course of rotation—viz.,—1, Weeded crops; 2, Barley; 3. Clover; 4, Autumnal grain—has been strictly followed. I have already said that the above-mentioned system is based on a misconception of the latter; in fact, it was introduced about that period when Frederick the Great, perceiving the advantages of the English system, caused it to be introduced upon his estates under the superintendence of an Englishman named Brown, and other experienced agriculturists whom he had sent to study in England; and he also endeavoured to introduce it throughout his dominions by assisting such landed proprietors and farmers as were disposed to entertain his views.

On some estates bordering on villages, we meet with a division into five parts or allotments, with great variation in the succession of the crops. As :—1. Autumnal corn. 2. Peas. 3. Autumnal corn. 4. Spring crop. This system of rotation is not faulty, provided always that the fallowing is complete and carefully executed. These quadrennial and quinquennial rotations might be much more easily converted into a good system of cultivation than the triennial, because in them the cultivation of plants for fodder occupies the proper place.

The summary of all the modes of tillage which I shall give in a tabular form at the end of this section will throw additional light upon the relation which the triennial rotation bears to itself and to other systems of cultivation, as well with respect to labour and manure as to the absolute produce.

### *Alternate Cultivation—Alternate Rotations with Pasturage.**

This species of cultivation, in which the land is devoted for several successive years to the growth of corn, and then for some others to the pasturage of cattle, or occasionally to crops of fodder for these animals, has been for a considerable period designated, by the English, Germans, and Italians, by the title of alternate cultivation, an appellation which is peculiarly appropriate to it. That which I have here designated "alternate cultivation and pasturage," comprises those rotations in which, after a certain number of years, the land is sown with grass seeds, or left to produce a spontaneous herbage for two or more years, when cattle are pastured on it. In Germany, this system of cultivation is generally called *koppel wirthschaft* (enclosure cultivation), even though the lands subjected to it may not be enclosed. For our own part, we shall reserve the term "enclosure" exclusively for land surrounded by hedges, applying the term "*sole F. Schlag G.*" (crop division) to each of those partitions which are made according to the rotations of crops, whether consisting of one separate and distinct piece or comprehending several, or only a portion of some more extensive division. According, therefore, to our acceptation of the term, the crop divisions are portions of land appropriated to certain successions of crops; and after the lapse of a certain number of years, or the term which the rotation lasts, each portion returns to the same state as at the commencement of the course. We shall not take the trouble to consider whether or not they are surrounded by hedges or fences, or even whether all the parts are united in the same place; a condition which is by no means essential, especially for stall-feeding, in which, under certain circumstances, diversity of position may be rather beneficial than otherwise.

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* In order to distinguish the subdivisions of this system in the north of Germany, the author gives the name of the "Holstein system" to that in which the years of pasturage predominate, and of the "Mecklenburg system" to that in which there are the greatest number of corn crops and fallows.

The chief recommendation of tillage alternating with pasture, appears to me to be a circumstance which all the detractors of this system have passed over in utter silence; namely, that these rotations embrace the whole extent of the arable land; those portions only which are too wet and which cannot be drained, or which are too hilly, or which are, perhaps, too far distant, are left unploughed; the former are reserved for meadow, and the latter for forest land, and each is devoted exclusively to that particular purpose.

To this advantage must be added, the increase in the profit derived from the cattle, arising from an abundant supply of food throughout the whole summer, and from the greater number of cattle which the extent and the richness of the herbage crops enables the farmer to maintain. Thus, then, even supposing that the produce in grain should not be at all increased, the increase in the profit of the cattle only, which no person can deny or doubt, would be quite sufficient to decide the question in favour of alternate cultivation and pasture.

The inhabitants of Holstein, that is to say, the greater number of them, for there are some few agricultural establishments there which are regulated according to the Mecklenburg system—the inhabitants of Holstein, I say, employ a greater number of crop-divisions and a longer rotation. They generally cultivate several successive crops of grain, and then lay the land down to grass, and leave it in a state of repose for a much longer period. The usual proportion in Holstein is, one-fifth autumnal corn, one-fifth spring corn, and three-fifths pasturage. If the land is fallowed, which is usually done since the practice of marling has been generally introduced, there is only one-tenth of the land fallowed. In that case the rotation is as follows:— 1. Oats on the broken-up pasture-ground. 2. Fallow. 3. Autumnal corn. 4. Spring corn. 5. Autumnal and spring corn. 6, 7, 8, 9, and 10. Pasturage.

There are seldom or never less than ten divisions, and we sometimes find the rotations extending over twelve, thirteen, and fourteen years, in which the years of corn crops and those of pasturage succeed each other without alternating, but with a far greater proportion of the latter, for they never cultivate more than five successive corn crops.*

The following are the rotations usually adopted in Mecklenburg:—

*The rotation of six years.*—This comprises one complete fallowing, three successive corn crops, and two years of pasturage. It is peculiarly adapted to estates which possess rich meadows and fertile pasture grounds. It requires a great deal of manure, either on account of the extent of the fallowing, which occurs every six years, or because two years of repose are not sufficient to restore to the soil that degree of fertility which it has lost by bearing three crops of grain. Whenever it has been practised on estates of only moderate fertility, it has invariably led to disadvantageous results, arising from the quantity of grain produced and the consequent exhaustion of the soil.†

*The septennial rotation* comprises one fallowing, three successive crops of corn, and three years of pasturage. This system is the one most in repute in the present day, because three years of pasturage allows the soil a sufficient term of repose, and the grass is most abundant in the third year; in consequence of this latter circumstance, the fallow can be much more efficiently manured than under the preceding rotation, and thus the soil gains the full portion of nourishment requisite for the production of three successive crops of grain. It certainly does not require less manure than the following one; nevertheless, it cannot be kept up without some accessory meadows. Latterly, some persons have attempted to introduce a fourth crop of grain; but if they do not possess rich pasturage, or separate lands for the growth of fodder, an injurious exhaustion must be the result, unless, indeed, very great discernment be exercised in the selection of the crops. We shall speak of this system more at large elsewhere; at present it is only our wish to give a mere sketch of those which are in common use in Mecklenburg.

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* The time that land can profitably remain in pasturage under the alternate system of cultivation, depends wholly on the quality of the soil. Good lands will produce a grateful herbage for many years, and even improve by lying at rest, while inferior soils will not hold good grasses above two or three years, and hence the necessity of renovation. Whenever a quantity of vegetable matter, less or more, has been profitably accumulated by the herbage, an opportunity is presented of deriving benefit from the action on future crops. From this circumstance the superiority of the system arises.

† The six years course of cropping and others following it, here mentioned, differs from the alternate rotations in Britain in having three or more grain crops in succession before grasses are sown, and without intermixture of the grain crops with the esculent and herbaceous plants, and, consequently, is wanting in the general benefits.

*The rotation of eight years* usually comprises one fallowing, four crops of grain, and three years of pasturage. It requires richer manure for the four crops of grain; and this can only be obtained from a larger supply of hay, because the quantity of straw progressively diminishes during the third and fourth crops. On estates which require to be improved after having been exhausted by cropping, this rotation is frequently made to include three crops of grain and four years' pasturage; and the same system is occasionally established upon exterior divisions which possess a moderate degree of fertility.

*The rotation of nine years* usually comprises one fallowing, four crops of grain, and four years of pasturage. There being only one fallowing in this rotation, and that occurring only once in nine years, the effect of it is less sensible than in any other. Besides, land which enjoys five years repose has much less need of manure, and therefore a smaller extent of meadow land is sufficient. It is true that this system provides little fodder for the winter maintenance of the cattle that graze during the summer over this wide extent of pasturage. Some agriculturists have made this rotation yield five successive crops of grain, and allowed only three years of repose and pasturage; but this course can only be supported on those lands which are exceedingly fertile, and such a system appears to us to evince rather a spirit of avarice and of covetousness than of economy.

The rotation of nine years with two fallowings, which was formerly so much in vogue, is now seldom or never to be met with; it was, however, productive of very fine crops of corn on tenacious soils which require a great deal of tillage.

It is only on the exterior divisions of estates where we meet with a rotation which embraces six years of pasturage, three corn crops, and one fallowing.

*The rotation of ten years*, comprising two fallowings, four crops of corn (the two first of which are separated from the last two by these fallowings), and four years of pasturage, is now only met with on a very limited number of estates. The smallest possible extent of meadow land is, however, quite sufficient to maintain the fertility of land cultivated according to this system. In my opinion, it is peculiarly adapted to a complete course of crops. If five successive crops of corn are raised upon land subject to the rotation of ten years, as has been sometimes attempted, the destruction of the soil, and, consequently, that of the rotation, is greatly precipitated.

*The rotation of eleven years.*—This yields two crops of grain after the first fallow, which, in the majority of cases, is not manured; in three years afterwards comes the second fallow, which is manured; consequently, there are four years of pasturage. This rotation was formerly preferred by the agriculturists of Mecklenburg to all others, and there are still many persons who do not repent of having adhered to it.

In good argillaceous land, where the deficiency of manure is compensated by repose and fallowing, this rotation may be made to yield sufficient nourishment for the cattle, and may be supported without much manure, and, consequently, with a very small extent of meadow land.

*The rotation of twelve years*, which yields three crops of grain after each fallowing, may, as far as the proportions are concerned, be compared with the rotation of six years; if it yields as much manure as the latter, a small portion of it may be taken from the first fallow, and the second will receive a more abundant supply. It seems to me to be superior to the rotation of six years, and for this reason, that the manure is saved where it would not be necessary, and where it might cause the corn to be laid, and is applied to the land in larger quantities wherever there is need of it.

If only one fallowing can be manured, that is to say, if the land can only be manured once in twelve years, the quantity of corn obtained will be very small in proportion to the extent of the sowings, and yet the soil will be sensibly impoverished.

With a very few exceptions, the general succession of crops of cereal plants which are raised is—autumnal corn only after the fallow; then two, three, and sometimes four crops of spring corn, the first of which is usually barley, and the others oats. But few vegetables are usually cultivated; when peas are sown, it is generally on the last field. When cultivated in that place, it cannot be expected that the produce will be very encouraging. The culture of other leguminous plants is still more rarely introduced.

In Mecklenburg it has not been found advantageous to allow the land to bear grass more than four successive years; the pasturage begins to diminish in the fourth year, and after that term the ground becomes covered with moss, and the cattle derive a very scanty subsistence from it. This is occasioned less by the difference which exists between the soils and climates of Holstein and Mecklenburg, than by the greater degree of impoverishment of the fields when they are laid down to pasture.

They seem to be entirely ignorant in that country of the method pointed out by Camillo Tarello, namely, that of not burying the dung until the last sowing, or of even spreading it over the new turf; in fact, the adoption of this plan, according to which the manure is only applied to the soil as a kind of capital, is perhaps considered to produce too great a diminution in the corn harvests, although the loss in that point will, in the end, be thoroughly compensated by the increased richness of the pasturage, and by the abundance of the produce which will be obtained when the ground is cultivated again.

Latterly, the practice of sowing white clover with the last crop has become very general: only a few apathetic and indolent agriculturists, or men who are firmly wedded to old opinions and customs, neglect this practice, and consider natural herbage to be quite as efficient and beneficial for the nourishment of cattle; but cow-keepers and dairy farmers are, almost invariably, great advocates of this practice, and their opinion ought to possess some weight.

It makes a very great difference in the pasturage of the first year, and the effects are even sometimes perceptible on that of the second and third. The produce of the pasturage ought to be valued both according to the nature of the soil and the greater or less disposition which it shows towards the bearing of grass, as well as according to the period which has elapsed since it has been without cultivation.

The testimony of a great many aged persons goes to prove that a wide extent of land, which had been wholly exhausted by the triennial rotation, has become so much ameliorated by this system of cultivation in the course of one generation, that it is now capable of producing a considerable surplus of corn for exportation, besides affording an abundant pasturage to three times as many cattle as were formerly fed upon it. This is so striking a proof of the superiority of the system over any other, that it has awakened the attention of all the provinces in the north of Germany, and has gained for it a great number of proselytes wherever the ancient laws and ordinances with respect to property do not restrict the free exercise of the will, and where the estates are sufficiently extensive to admit those great changes which can only be made gradually, and, during the first years, with a sacrifice both of money and of produce.

The following are the principal advantages of the system of alternate cultivation and pasturage:—It saves a great deal of labour, and that which is applied to it is always more profitable than that which is applied to the triennial rotation, in which land that has not been manured is too often ploughed in vain, since it gains little more than the equivalent of as much more as the seed. The operations succeed each other in regular succession, being the same every year and also equally divided among the different seasons. Each ploughing can be performed at the period which is most proper for it; and as the time at which the land ought to be broken up occurs about autumn, it is easy to choose the most favourable periods for ploughing and harrowing. It is a common saying, that if any one wishes to see land carefully and perfectly fallowed, he must travel through Mecklenburgh. The manure is applied to the soil at the most suitable time, and it is carefully mingled with the upper layer in order that the action on the crops may be direct and complete as possible. Everything is in readiness for the autumnal sowing, so that the first favourable moment which occurs may be embraced for putting the seed into the ground; a circumstance which has considerable influence on the success of the crop, and the other rotations do not possess the same advantage.

The diminution in the amount of labour has been made a matter of reproach to this system. It is said to be detrimental to general industry, and calculated to diminish the population. But this complaint can only be made by those who do not consider or recollect that under this system no one portion of the land is suffered to lie uncultivated, but that it embraces the whole extent of the domain, deriving from each portion that kind of produce for which it is best calculated. If the population of Mecklenburg has diminished since it was first introduced, which certainly is not the case, that result could only have been attributed to the great extent of the estates, and to the scarcity or total want of small farms.

Besides the regularity in the quantity and nature of the agricultural labours in this system, the crops will, if we except extraordinary years, be found to be always similar, and that not only with respect to extent of ground, but of the absolute produce; at any rate, the difference in the production of certain years is not so sensibly felt in this system as in many others. The autumnal corn seldom or never turns out badly, because it is sown early and at a proper period. Unless any unforeseen accident occur, the amount of the products may generally be reckoned with tolerable accuracy. It is for this reason that those excessively abundant crops, which no one can account for, are seldom obtained from any portion of the fields, and the certain and regular net produce which may be expected from the estate can be calculated with a much greater degree of certainty than under any other system.

In proportion as a judicious distribution of the lands and a permanent introduction of this system of cultivation require knowledge, intelligence, and skill, in like proportion will be the facility with which it can be carried on when it is once fairly established. Very extensive agricultural undertakings may be put in train by these means, and kept in good condition by a very trifling amount of surveillance. Everything has its proper course, and all the operations succeed one another in their fitting times and places. There is nothing to be attended to but the ordinary routine of the operations of ploughing, harrowing, sowing, reaping, mowing, and gathering in the crops; and these details are so well understood, and, in general, so well executed, that every upper labourer, bailiff, or over-looker, even if he can neither read or write, is perfectly capable of conducting and directing them.

The cattle which are kept for profit or income are usually farmed out, and it is the business of the dairy-farmer to look after them; and his interests lead him to pay particular attention to the meadow land, and to raising crops of fodder. In summer these cattle have their regular pasture-grounds, and in the winter they consume all the hay and straw which the draught cattle do not want. Even if the year has been otherwise unfavourable and the fodder has been rather scanty, the farmer need not trouble himself about anything else while he is sure that the animals will not want for actual necessities. The cowkeeper, in contracting for the farming out of his cattle, always takes care to stipulate that, come what may, they shall have a sufficient if not a plentiful supply of food.

It is very evident that, with this regular course of cultivation and this equality of products, the profit derived from agricultural industry can never be very considerable. An estate produces a certain income; which latter is, on an average, almost equal to the net produce of the cultivation. An estate which is completely arranged, and which does not possess any peculiar or undiscovered resources, may be safely purchased; but if the same course of cultivation be continued on it, it will be impossible to make it yield more than the amount of the rent, unless indeed some extraordinary combinations of circumstances raise the price of corn considerably beyond the natural value.

I do not mean to infer that a skilful and reflective man may not, by means of judicious and well-directed ameliorations, find opportunities of materially improving many estates, and deriving considerable advantages from them. But this is quite distinct from cultivation, properly so called, and can only be carried into effect in certain localities. Although a great number of experiments of this nature have been made with variable results, and although it is evident that they cannot always be attended with success, yet there doubtless are numerous resources yet undiscovered on estates at present submitted to this species of cultivation.

The regularity with which the agricultural operations appertaining to this system are performed is so great, that by means of it any person may easily direct several separate estates at the same time, without the necessity of having a skilful over-looker for each. It is sufficient occasionally to see that the machinery continues to work, and to accelerate the motion at times when it appears necessary. The book-keeping is very simple, clear, and concise. In Mecklenburg there are many farmers renting large estates, who keep their whole accounts on their door posts with a piece of chalk.

Besides that the work is distributed in a more uniform manner under this system than under any other, it is also much less in amount. This is one reason that the rotation is so well adapted for those situations or districts in which there is a scarcity of labourers, and especially where it is difficult and often impossible to engage supernumeraries in the hour of need. Every year it employs the same number of labourers and of draught cattle; and if the services of the persons whom it employs at one period are not required at another, they at least know what to expect, and will take care to seek some other occupation during the intervals of labour.

In less cultivated and less populous countries, where estates comprising large extents of land, often of little or no value, render the *great culture* incontrovertibly preferable to the *small*, this system will be found far more convenient and advantageous than any other. It has this merit, that at any period it may be totally changed; that it forms an excellent precursor to any other rotation; and that it also prepares for an advantageous division of large estates, since any peculiar cultivation may easily be introduced on any portion of ground lying at rest.

In Holstein the produce from the cultivation of grain is too small and not proportionate to the nutrition and succulent juices contained in the soil. In Mecklenburg, on the other hand, the defect that exists in cattle economy does not belong so much to the number of animals, but arises from a want of sufficient nourishment for them in summer as well as in winter. The results of this defect are, not only the absence of a satisfactory profit from this branch of rural economy, but, what is still worse, a scarcity of manure, which, if the cultivation were ever so good, would alone be sufficient to prevent the crops from being so fine and so abundant as they might be if the soil were properly manured.

Besides, under these two methods of cultivation, the produce, both in grain and in straw, is greatly diminished by the circumstance of three, four, and sometimes more crops of corn succeeding each other without interruption; and although the Mecklenburg farmer may, after the fallowing on which he bestows so much care and labour, obtain as fine a crop of autumnal corn as the quality of the soil will enable it to bear, yet the other crops, and particularly the third and fourth, are so poor and scanty that in general they are thought to produce well when they yield from four to four and a-half times the amount of the seed. If a more judicious choice of crops was introduced into these two systems, there is not the least doubt that the land would yield a much greater profit both in vegetable and animal products; and this change might be carried into effect, as it has been by several agriculturists, without the necessity of making any sensible alteration in the established division, or of introducing the practice of stall-feeding, which seems to be attended, as yet, by so many difficulties.

In order to demonstrate the suitableness of these changes as clearly as possible, and also to point out what ought to be their nature, we will here endeavour to give a precise idea of one of the most essential parts of agricultural science, viz., the manner in which the crops should be made to alternate; this subject, however, ought, properly speaking, to be included in the remarks on cultivation and on the propagation of vegetables.

### *On the Succession of Crops.*

Even during the most remote periods, it was remarked, by attentive observers of field and garden tillage, that the soil produced incomparably finer crops when these were constantly varied, and when two of the same kind were not suffered to succeed each other in the same place; and that, according to the nature and condition of the soil, one series of crops proved more advantageous than another. Whenever the cultivation was confined to one plant, or to plants of one particular species, it was always judged necessary that the soil, after having produced a certain number of crops, should be left in repose; that is to say, it should be allowed time to reproduce and collect the succulent matters which were proper for the nourishment of the crops it had to bear. Manure and cultivation certainly tend to facilitate and advance this action, but nature requires time also in which to collect and renovate her exhausted energies. The gardener, who frequently changes the nature and species of his crops, certainly is not obliged to have recourse to repose; but the mere farmer, whose only aim is to raise corn, must, unless he manures his land extravagantly, allow it a certain period of rest. In those places where the improvements in agriculture have raised the price of land, it is easy to see that this increase of price does not proceed from any difference in the laws of nature as applied to the soil of fields and gardens, but only from the farmer having learned to manage his cultivation so as to be able to produce, alternately, all the crops which he requires. The ancients founded their agriculture on the lessons of experience, and they raised it to such perfection as to be able frequently to make the same land yield two crops in one year. The Romans were well aware of the beneficial effects of careful tillage and exposure to the influences of the atmosphere on land that was destined to bear only wheat, barley, and oats, or other grain of this kind; but they also know that

Mutatis quoque requiescunt fructibus arva,
Nec nulla interea est inaratæ gratia terræ.*

Hence arose the following question: — "Which are the crops which can be made to succeed one another with the greatest advantage, and which are those that have the tendency of preparing the soil for the one which is to follow?" This problem is the more difficult of solution because experience affords us so many contradictory answers, which, however, without doubt arise from the variations which exist in the soils and climates of different localities and countries. From the very earliest periods of natural history, attempts have been made to resolve this question in a theoretical manner either by analogy or by inference, or both, and this second problem has been put forward:—"What, if each different kind or species of plant requires some elements of nutrition peculiar to itself, and from which alone it can derive the requisite degree of nourishment; and what if it be impossible that it can succeed on any soil which does not contain these elements?" The careful examination of numerous facts and experiments ought to lead us to answer this question in the following manner:—It is a well known fact, that each plant does not require peculiar elements for its nutrition, but that its own organs digest and assimilate to it those juices which they extract from all those component parts of the soil which are destined for the nutrition of plants in general. Vegetables whose properties are the most opposite—plants the most corrosive and venomous, as well as those which are most beautiful and useful—those the most opposite in variety and contradictory in nature—will be found growing on the same soil and flourishing together, a thing which never could occur if they required different nutritive matters for their support. In short, all varieties of plants, and all their various parts and juices, are composed of the same substances, a fact which has only lately been discovered. The constituent parts of all organic substances are carbon, oxygen, and hydrogen, with which a small portion of azote is generally united, but very few of them contain any great quantity of this latter element; plants also contain earth and potass, and some few contain phosphorus and sulphur. These constituent parts are to be met with in every fertile soil, even if they are not imbibed directly from the atmosphere. By means of the functions and operations of their different organs, the plants assimilate these matters to their own substance, and form all those various combinations of them which are found in the infinite variety of vegetable products. From these facts the erroneous inference has been deduced, that a soil which contains all the requisite elements for the nutrition of one plant ought necessarily to have in it those that are proper and suitable to others, and that the fertility of a soil is produced merely by the physical contexture.

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* Your fields would repose equally as well if you changed the crops, and then you would not have to pay the rent of land which bore no crop.

But theory alone is quite sufficient clearly to demonstrate the truth of the contrary opinion; namely, that the plants contain and combine these substances in very different degrees. It is possible that the roots or suckers of all kinds of plants possess a sensibility and a power of choice, which enables them to imbibe and appropriate to themselves the exact proportion of each of these substances which nature leads them to require for their support. But in order that they may succeed in accomplishing this purpose, it is necessary that they should be enabled to meet with the proper proportions and combinations of these substances within their own immediate sphere. If this proportion does not exist, or if some of these substances are present, but not in sufficient quantity or in that degree of combination which the plant requires, then its growth will be slower and it will not thrive so well. In a soil which, although not entirely without some one of these substances, yet does not contain a sufficient quantity of it, the plant must put forth its roots in every direction to seek and absorb that which is absolutely necessary for its nourishment. It is not improbable that the soil may contain too great a proportion of some one of these necessary substances, and that the plant being thus suffocated by the superabundance of it, and the scarcity or total absence of all the others, may fall from weakness and not thrive.

This reasoning clearly explains the fact that a succession of crops of the same nature always fall gradually off, and become less and less productive, if cultivated in the same place, even when the soil contains all the component parts usually considered necessary for their nutriment; and also the reason of the fact that they regain their perfection so soon as the soil has been suffered to repose, and are made to produce some other crops, and of an ameliorating nature. It is easy to suppose that a plant which absorbs a diametrically opposite proportion of elementary substances to that which is required by another, will tend to establish the proportion which is best adapted to the latter, and will cause it to thrive far better than it would have done if the soil had not received this preparation, and had been deprived of some of its nutritive qualities. A soil may be completely exhausted by means of this alternation of crops, so much so indeed as to be incapable of affording nutriment to any plant; but it is exhausted much sooner if one particular species only is cultivated on it. (Einhof, "Annal of Agriculture of Lower Saxony," Vol. viii. p. 321.)

If various kinds of plants vegetate on one soil at the same time, there can be no doubt that they will yield much less than they would do if cultivated separately and singly; for, without taking into consideration the space both above and below the surface of which they deprive each other, one must absorb some portion of those substances which are necessary to the support of vegetable life in general, and, consequently, the others are deprived of it.

But let us return to the data afforded us by experience: here we find that all skilful gardeners, and many farmers, are agreed upon one point—namely, that it is advantageous to cultivate some plants together; that far more abundant crops of them are thus obtained than would be the case if they were cultivated separately and on distinct portions of land.

In places where the art of gardening is carried to the greatest perfection, five or six different kinds of products may frequently be found growing on the same bed; and according to the unanimous assertion of all skilful gardeners, an assertion which is founded on experience, this proceeding is attended by a considerable saving both of soil, manure, and labour.

In many countries this system has been applied to the cultivation of fields and of arable lands, and these intermixtures of crops have been raised with various degrees of success.

Any kind of vegetable, as beans, peas, or vetches, if sown in conjunction with some kinds of grain, as spring rye, barley, or oats, will yield a far more abundant crop than if the two were sown separately. It has long been known that leguminous plants when sown among corn on a soil which is so arid that they could not have vegetated alone, will yield well without sensibly diminishing the corn crop. Thus, according to the experience of the majority of agriculturists, wheat intermingled with rye may succeed on land which cannot be made to bear wheat alone; and when sown in this way the wheat crops are finer than they would be in places where they can be cultivated without any other grain. This admixture also succeeds when it is sown on wheat stubble, where every one knows from experience that wheat will not thrive alone, even when the soil is otherwise perfectly adapted for its growth.

Experience likewise confirms this hypothesis, that by means of an intermediate crop of some other nature, that true proportion of the elementary substances which is suitable to one particular species of grain may be re-established. We have just now stated that wheat sown on wheat stubble never succeeds. Wheat sown after barley does not thrive well, unless the soil was so excessively rich that it needed this preliminary crop to render it suitable to the wheat. Rye sown after rye succeeds better, but even then the produce in grain is considerably diminished.

But if a crop of some of those plants belonging to the class *diadelphia*, as peas, vetches, beans, or clover, be interposed, then the second crop of the cereal plants will turn out well; and if the leguminous plants are cut while green, or if the second cutting of the clover is ploughed in, there is every probability that the second crop of grain will surpass the first. The truth of this principle has been so clearly demonstrated by experience, and is so well known to every attentive observer, that I shall refrain from adducing any further examples or entering at greater length into the subject, and the more especially as I must return to it when I come to treat of the cultivation of each plant separately.

The cultivation of gardens sufficiently proves that when the soil has lost the power of reproducing one species of vegetable, it is not exhausted, but may be made to bear others with success. Beds of earth, after having produced several crops of one kind of plant, lose every faculty necessary for its reproduction, and cannot be made to bear it again until they have been exposed for several years to the fertilizing influences of the atmosphere, and impregnated with fresh manure; but they are still capable of bearing French beans, lettuces, and other vegetables. Sweet-scented and ornamental flowers, as violets, &c., require that the earth contained in the pots in which they grow should be frequently renewed, even although it may seem to contain an abundance of nutrition; the florist never sows the same kind of flowers twice in one place, neither ought young fruit trees ever to be planted in the same spots where others of the same kind have stood. In nursery grounds it is an invariable rule that the soil shall be changed at each renewal.

Herr Einhof and myself have frequently prepared some experiments which might enable us to determine the nature and degree of the changes which the mould undergoes in a soil in which one plant has been cultivated, until every element necessary for its reproduction is exhausted. But we have always been interrupted and thrown out in these experiments, which, from having to be made in the open air, are attended with very great difficulties, and present obstacles which nothing but the most uninterrupted attention can overcome. In fact, there is no known means of guarding against those various accidents which, in one moment, will destroy the work of years and leave no satisfactory result behind. In order to succeed, the experimentalist ought to possess a garden enclosed with the most scrupulous care, devoted solely to his own purposes, and from which it was possible to exclude both birds and insects.

It has generally been observed, that if any crop fails or yields a scanty produce, not from impoverishment or any other defect in the soil, but merely from some accidental cause, the same kind of plant will, if sown in the same place in the following year, succeed far better than it would otherwise have done. Again, a crop which succeeds one which formed a good preparation for it will thrive and yield the more abundantly in proportion as the former was productive; such, for example, is the case where wheat is sown after clover or beans. The more abundant the produce which a plant yields, the greater will be the degree of exhaustion of the soil which has produced it, if the same plant is sown on it again; but such will not be the case if it is succeeded by a crop of another kind, and there are many instances in which an abundance in the first crop has proved rather favourable than otherwise to the successor.

That which appears to exhaust land most is the formation of grain, seeds, and other farinaceous substances. All herbaceous plants, therefore, if cut in their green state and taken off the ground at the time of flowering, and of the most vigorous vegetation, will absorb little or no part of the nutritive juices contained in the soil, but on the contrary, they seem in some respects to ameliorate it: this is a truth of which every day affords new proofs to those who will bestow the pains of attentively considering the works of nature. It has not yet been decided whether a plant does or does not absorb a greater quantity of nutritive matter, and particularly of carbon, from the soil during the period which the grain takes to ripen; but it is well known that during that period all the mucilage and juices secreted in the stalk and root, are yielded up to the grain, and the former become converted into mere filamentous substances. It is not, however, a matter of indifference whether the root and stubble which remains in the ground has preserved the vitality and nutriment, or whether it is dry when the stalk is detached from it; because, when the former is the case, the nutriment contained in those parts of the plant which still remain attached to the soil, is still further augmented by the carbonic acid gas which the stubble absorbs and communicates to the earth, and consequently the soil is more ameliorated. In the cultivation of spergula, as an intermediate crop, it has frequently been remarked that the roots have this effect. If this plant is mowed while green, it ameliorates the soil very considerably; some persons pretend that if it is pulled up, as is sometimes the case, the exhaustive powers are in equal proportion. This is, perhaps, the cause of the exhausting effects which are attributed to a crop of flax. These facts are so well attested, that it is not worth while to consider all those doubts which contradictory spirits have raised with regard to this matter.

However, I shall not permit myself to carry out this theory so far as some persons when they positively assert, that the soil is not deprived of any portion of fertility and nutritive power by those productions, the vegetation of which is arrested before the formation of the seed has commenced. All kinds of tuberculous plants collect within their root or bulb, a store of alimentary juices for the nourishment of their shoots in the following year; these roots form a species of magazine from which these biennial plants derive the nutrition which is necessary for the production of their flowers and shoots in the ensuing spring. Both experience and trials have tended to prove that if these roots are left to decay in the soil, the effect on it is exceedingly beneficial. If they are gathered, they certainly subtract some portion of the nutrition contained in the soil; although, on the other hand, they mechanically ameliorate it by means of the cultivation bestowed upon them, and thus form an excellent preparation for other crops. When vegetables of this kind leave their roots, stalks, and some portion of their leaves in the ground, they restore to it a part of that nutriment which they have absorbed during the process of their vegetation.*

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* The theory of the rotation of crops is of so much interest to the agriculturist, that we shall make no apology for repeating in this place what we have elsewhere had occasion to remark ("Farmers' Encyclopædia"):—

"When cattle," says Davy, "are fed upon land not benefited by their manure, the effect is always an exhaustion of the soil. This is particularly the case where carrying horses are kept on estates; they consume the pasture during the night, and drop the greatest part of their manure during their labour in the day-time. The exportation of corn from a country, unless some articles capable of becoming manure are introduced in compensation, must ultimately tend to exhaust the soil. Some of the spots, now desert sands in northern Africa and Asia Minor, were anciently fertile; Sicily was the granary of Italy, and the quantity of corn carried off from it by the Romans is, probably, a chief cause of its present sterility."

The same theory is also supported by M. Liebig. In his excellent work on "Organic Chemistry," p. 158, he remarks:—"It is evident that two plants growing beside each other, will mutually injure one another, if they withdraw the same food from the soil. Hence, it is not surprising that the *Matricaria Chamomilla* and *Spartium Scoparium* impede the growth of corn, when it is considered that both yield from 7 to 7.43 per cent. of ashes, which contain $\frac{6}{10}$ of carbonate of potash. The darnel and the *Erigeron acre* blossom and bear fruit at the same time as the corn; so that when growing mingled with it, they will partake of the component parts of the soil, and in proportion to the vigour of their growth that of the corn must decrease, for what one receives the others are deprived of. Plants will, on the contrary, thrive beside each other, either when the substances necessary for their growth, which they extract from the soil, are of different kinds, or when they themselves are not in the same stages of development at the same time. On a soil, for example, which contains potash, both wheat and tobacco may be reared in succession, because the latter plant does not require phosphates, salts which are invariably present in wheat, but requires only alkalies and food containing nitrogen. According to the analysis of Posselt and Reimann, 10,000 parts of the leaves of the tobacco plant contain 16 parts of phosphate of lime, 8·8 parts of silica, and no magnesia; whilst an equal quantity of wheat straw contains 47·3 parts, and the same quantity of the grain of wheat 99·45 parts of phosphates."

The late George Sinclair took a similar view of the cause of the exhaustion of soils. "If," he says, "a plant impoverishes a soil in proportion to the weight of vegetable matter it produces on a given space of ground, the following will be the order in which the under-mentioned plants exhaust the ground, being the proportion they bear to each other with respect to weight of produce:—

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|---|---|
| Mangel wurzel | 25 |
| Cabbages | 25 |
| White turnip | 16 |
| Potatoes | 15 |
| Kohl-rabi (bulb-stalked cabbage) | 14 |
| Swedish turnip | 13 |
| Carrots | 11 |

But when we take the weight of nutritive matter which a plant affords from a given space of ground, the results are very different, and will be found to agree with the daily experience in the garden and the farm.

The following figures represent the proportion in which they stand to each other with respect to the weight of nutritive matter per acre, and in exhausting the land:—

Independent of their chemical qualities, the long cylindrical roots of these plants produce a mechanical effect which is extremely beneficial to tenacious and argillaceous soils. Deprived of life, and yet not decomposed, they have the same effect as small pipes, keeping the soil loose and friable, and enabling the atmospheric air to penetrate into all the interstices. They loosen the soil as much as repeated ploughings would do; and after a crop of these roots, it will only require to be ploughed once before the seed is sown in it.

General experience thus seems to prove what has long been my firm opinion, that even if we do not admit that these vegetables require a different proportion of alimentary substances, they will not, when allowed to reach maturity and to bear seeds and flowers, take from the soil much more than they bestow on it in other ways. But if they are cut while green and before the seeds have begun to form, it cannot be denied that they materially enrich the soil and render it capable of bearing crops, which it could not previously have supported.

Although those vegetables which are comprised under the denomination of weeded plants deprive the soil of some portion of its nutritive power, and render it necessary to manure more abundantly in order to remedy this defect than would have been requisite if it had been submitted to the operations attendant on a naked

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| | |
|---|---|
| Potatoes | 63 |
| Cabbages | 42 |
| Mangel wurzel | 28 |
| Carrots | 24 |
| Kohl-rabi | 17 |
| Swedish turnip | 16 |
| Common turnip | 14 |

Change of crops also prevents very materially the increase of the predatory grub and insects which also more or less prey upon the farmer's crops. The parent of the wire-worm, for instance, which is the larva of a small beetle, the *Elator segetis*, may be seen in the summer months, depositing its eggs on lays or meadows abounding with the cereal grasses; for instinct teaches it to place its eggs where the young wire-worm will meet with its natural food, which are the cereal grasses. Change of crops, therefore, not only checks the deposit of the eggs, but by removing the natural food of the young vermin, it materially prevents increase, or even their continuance; which otherwise, as is the case, for instance, with the wire-worm, might for four or five years be a pest to the soil.

fallow; nevertheless, by means of the cultivation which is bestowed on them, if proper implements for the purpose are used, they will form a very advantageous substitute for a fallow, and will tend to loosen the soil, expose it to the fertilizing influences of the air, and effect an intermixture of the various constituent parts with considerably less labour than could be done in any other way. If the farmer chooses to have them dug up, a portion of the inferior layer of the ground will be brought to the surface, and the destruction of the weeds will be thus effected. All these things may, with judicious management, be equally as well attained by the cultivation of these roots as by fallowing the land; and the additional amount of food which these crops provide for the cattle, and the consequent increased quantity of dung yielded by the animals, will more than compensate for the extra manure they require. And if, as is customary in England, the cattle intended for fattening are made to eat them on the ground, the amelioration thus retained is fully equivalent to a complete manuring. When the English speak of long rotations without manuring, there are always plants of this kind interposed between the corn crops. Although this mode of proceeding appears to savour more of stinginess than real economy, it is not without its advantages, as the cattle thus fattened most certainly pay the rent of the land and the expenses of the labour, if they do not yield some further profit; whereas a fallow, so far from yielding any profit, costs a considerable sum.

Those root-crops which belong particularly to this class of economical plants have this peculiarity: they form a better preparation for barley than a fallow, but they do not form a good preparation for autumnal corn. This may arise, in a great measure, from their having a tendency to retard the seed-time. Several crops of grain may be raised in the same rotation without the addition of fresh manure, if one crop of leguminous plants be interposed between two of corn.

If, however, vegetables are cultivated instead of these roots, and are carefully tilled with the horse-hoe, the autumnal corn will succeed equally as well after a crop of beans, especially on argillaceous ground, as it would after a fallow, and, in the opinion of many persons, much better. Thus in Kent, where so great a quantity of wheat is cultivated, beans sown in rows are considered as the best preparation which the ground can receive. Many vegetables which yield advantageous produce and particularly cabbages, if transplanted or sown in rows, may be substituted, if a sufficient quantity of manure can be procured, and if there is a superabundance of fodder.

In order effectually to destroy weeds, it is of importance that the various kinds of grain should be sown alternately; because some of the cereal plants favour the growth of noxious weeds far more than others. This is a very important subject of consideration before making choice of a rotation for any piece of ground, and especially if it is infested with weeds, as by means of a judicious selection of crops the land may sometimes be completely cleared.

These facts and motives form the rules by which we ought to be governed in our choice of the crops which are to form a rotation; but, while arranging this matter, the cattle, and the fodder requisite for their sustenance, must not be lost sight of, and ought to be considered under two points of view: first, with regard to the profit which may be derived immediately from them; and secondly, to the advantage which may be derived from the manure which they produce.

Those rules which lead us to select certain alternations of crops do not, as some persons have supposed, require that half the fields shall be exclusively devoted to the cultivation of plants for fodder. There are many places even in England where the alternate succession of crops has been practised from time immemorial, and where, so far from cultivating vegetables for fodder, they even sell the straw at the market towns, and keep few, if any, cattle, because the marine and aquatic plants thrown on the coast and mixed with mud and slime, collected with great care, furnish them with an abundance of manure. The inhabitants of these places principally cultivate and alternate crops of podded plants with the cereals, a portion of which they send to the London market.

But, at any rate, these rules require the most judicious care and management: they mostly need that a large portion of the fields shall be devoted to the cultivation of fodder for cattle, because the abundance or scarcity of the manure which they will produce depends entirely on the nature and quantity of the fodder which they receive; and the manure again, in its turn, exercises a powerful influence on the crop of grain. It will sometimes be found that great and durable advantages arise from the choice of a rotation, in which one-half, two-fifths, three-eighths, or four-sevenths of the whole is devoted to the production of plants for fodder; while, in other cases, one-fourth, one-fifth, or one-sixth part will be found to be quite sufficient, and all the rest of the land may be appropriated to the growth of products destined for sale, and alternated in the proper manner.

However evident the propriety of such a proceeding may have been, very few persons ever thought of modifying the quadrennial rotation; and, instead of sowing first autumnal-corn, then spring-corn, and then peas, to sow first autumnal corn, then peas, and then spring corn, and then fallow. But those agriculturists who have pursued this course find that it answers exceedingly well, as they obtain an additional quantity both of grain and straw. Many German agriculturists, and especially Eckart, in his "Experimental Economy," have approached very near to this practice; but in the present day many persons are so blinded by prejudice that they cannot see the most palpable objects, or rather that they obstinately shut their eyes to everything which appears to be in contradiction to their preconceived opinions.

Woellner and Germershausen also advocate this rotation of crops. But though almost every farmer well knows that the grain crops are improved by being varied and separated by others of a different kind, and no one refuses his assent to this opinion as a theory, yet how very few, if any, can be brought to renounce the old triennial rotation. The greater number of adherents are certainly prevented from leaving it by laws which compel them to follow this established system; but there are many proprietors, both of small and extensive estates, who have the liberty of cultivating their lands according to their own discretion.

For my own part, accident and necessity, and not the perusal of any publication on English agriculture, or any reflection on the subject, led me to adopt this alternate, perfectionated system of cultivation. As I have been honoured with the title of the father of this system in Germany, I trust I may here be permitted to relate the circumstances which induced me to adopt it. I was an ardent disciple of Schubart's system of clover and stall feeding, and consequently wished to introduce that plant into my rotation, and to cultivate it during the third year instead of fallowing the ground. But it did not succeed; the field became infested with weeds; the autumnal corn which I sowed, after a single ploughing, completely failed, although I manured the land after ploughing the clover, and it had been already manured in the previous winter. With the assistance of a tolerable field of lucern and green oats, I obtained sufficient green food to keep my cattle during the summer, but in the winter I felt the want of the fodder I had expected to derive from my field of clover; all that I had to give them was some potatoes and turnips, grown on the lucern field after it was broken up, and a small quantity of natural hay. Filled with gratitude to these two vegetables for the valuable assistance they afforded me, I had a portion of that land on which the clover had failed broken up and planted with potatoes. The crop yielded by these roots was abundant, but late; and as the weather proved wet and unpropitious, I was not able to sow rye on this ground, as had originally been my intention. I therefore sowed barley on it the following spring; and, as I was fully determined to have a supply of clover, I sowed the seeds of it thickly with the barley. The following year I had some good clover for the first time; while another field which had been manured during the winter, and on which the clover had been sown after a second crop of grain, produced very little besides sorrel. After yielding a miserable cutting, this last-mentioned field was ploughed three times previous to being sown with rye; while the former was ploughed only once after having yielded a second cutting of clover, and yet it produced a decidedly finer crop of rye than the other; and these circumstances had the effect of determining my choice of a rotation.

Nevertheless, I was far from attaching any value to it beyond that of peculiar adaptation to my own circumstances and situation. On the contrary, I felt some degree of shame at the idea of becoming a disciple of the system advocated by Pfeifer, Meyer, Schubart, and Gugemus—a mere grower of potatoes and an imitator of all the petty gardeners in my neighbourhood who cultivated their acre of ground, and all, as nearly as possible, in the same manner. However, when I came to consult and converse with them, I found that their experience coincided entirely with my own. I made only one difference, namely, the introduction of a hoe from Mecklenburg, for the purpose of bringing the mould round the roots of my potatoes, and which has now come into general use throughout Germany.

It was not until some time afterwards that chance threw in my way the works of some of those English authors who regarded this rotation, or a similar one, as the only basis of good cultivation; who advise that the fallow should be replaced by crops planted in rows, and carefully tilled; and consider clover to be only an ameliorating crop when, sown with the first crop of grain, it finds the soil thoroughly loosened and cleaned by the fallow crops, and, consequently, vegetates so thickly and luxuriantly as to cover the whole surface of the ground with a shade; and who, when this is the case, regard the cultivation of this plant as an excellent preparation for wheat; but who would deem it a transgression of all the principles of good agriculture to sow wheat on any place where the clover had turned out badly, at least until that spot has been allowed to rest for a time, or been cleaned by a summer fallow. I thought it my duty to make this system known to the German public, and also some English experiments, which I learned were made about the same time, and which seemed to coincide with my own views. I accordingly published it, first in the Hanoverian Magazine, and subsequently in my "Introduction to a Knowledge of English Agriculture."

It is not, therefore, entirely without reason that this rotation has been designated the *English system*, although it is not in general use even there, but is only practised in some particular counties, and on the estates of some few enlightened agriculturists, whence it will doubtless become every year more and more diffused.

The following are the principal advantages of this system of cultivation: —

1. The abolition of the dead fallow; in the place of which, after a certain number of years, plants are cultivated either as fodder for cattle or for sale, which, during their vegetation, admit light ploughings, or tillage with the hoe or horse-rake being applied between the rows both lengthwise and across, by which means the soil obtains as much benefit as it would receive from a fallow. There certainly may be some fields which will require a dead fallow at the commencement of this rotation; but that operation having once been thoroughly performed, they never ought to need a repetition of it. The principal amelioration ought to be bestowed on this first division; every particle of manure which can be spared should be devoted to it, and the quantity bestowed ought to exceed that which would be proper for any other species of crops; indeed, it is almost impossible that these crops can be too plentifully manured. This manure tends to divide the soil and also to destroy all the germs of weeds which are contained in it.

2. These weeded crops ought to be succeeded by spring corn, first, because it is usually so late before they are removed that there is not time left to sow autumnal corn; and secondly, because, in general, experience teaches us that the former yields a much finer crop than the latter, especially on argillaceous land, and also leaves the soil in sufficient condition to bear a succeeding crop of autumnal corn. This spring corn may be wheat, oats, or barley; the latter is most usually sown, and especially a species of rice barley, or two-rowed barley, or barley without skin *(Hordeum celeste nudum)*. Should the soil, either from not having been sufficiently cultivated, or in consequence of a very wet summer, not have been properly cleaned and divided, we must, in this particular case, give the preference to the small or four-rowed barley, because it allows time for the ploughings to be repeated before the sowing takes place. But, in general, these ploughings are so wholly unnecessary that the spring sowings require little preparation besides that which may be given with the extirpator or harrow, which, in this season, when there is usually such a press of labour, is a very great advantage.

Many persons fear that the spring cereal plants will be laid if they are sown on so rich a soil; but experience ought to reassure them, such will never be the case if they will only take care not to sow the seed too thick—a practice which is at once superfluous and highly injurious. Deep ploughing will always prevent the corn from being laid.

3. The following fundamental rule must not be lost sight of, namely, that two crops of grain should never be allowed to succeed each other; but that they should always be separated by an intervening crop at least, unless it occurs at the end of the rotation, when the fallow crops are to succeed, and the products cannot be so much injured by the grounds being hardened and infested with weeds.

The farmer must be guided in the selection of these intervening crops by the number of the divisions of land, and by the wants of the establishment. They may be composed of clover, vegetables, oleaginous plants, and, in short, of any kind which does not belong to the gramineous class.

4. It is absolutely necessary that clover should be sown on a good soil which has been well tilled and thoroughly manured. It is usually sown with the crop which succeeds the weeded plants. Where this is the case, there is no reason to fear the success, provided it is sown in a proper manner: the roots then penetrate so far into the soil which has been deeply loosened, that it has little to fear from the inclemency of winter; and the old saying with regard to clover, doubtless founded on experience, that the soil becomes tired of it, is not applicable here, since the experiments of twenty years may be adduced to prove that although it should be sown in the same place every fourth year, it will flourish better in each successive crop.

5. In rotations of longer duration, in which the agriculturist endeavours to obtain the utmost possible quantity of manure and of fodder, and to bring the soil into the highest possible degree of fertility of which it is capable, it will be found very advantageous between two crops to raise one which shall not be suffered to arrive at maturity, but is mown while green for the purpose of feeding the cattle. Vetches and buck wheat are best adapted for this purpose, as the stubble leaves the land thoroughly prepared for the reception of the autumnal corn. By means of products of this nature, it is possible to obtain in the same year,

Double crops. With this system of cultivation there is no doubt that it would be possible to obtain double crops on several divisions at once; but in the climate of the north of Germany and on extensive farms which cannot command a sufficiency either of labourers or of teams, it is not so easy a matter as at first sight it may appear to be.

Crops of roots sown on the ploughed stubble of autumnal corn certainly do sometimes succeed very well in this country; but, in order to obtain a crop, they must be sown very quickly, and in the midst of all the numerous labours that attend the period of harvest. I cannot from my own experience offer an opinion with regard to the practice recently so much vaunted, of sowing carrots in the spring among the autumnal crop of rye; and I cannot discover any trace of the existence of such a practice among the English, who are generally endeavouring to multiply their crops as much as possible. I am perfectly well aware that it is by no means difficult to obtain a second crop in a field of beans or maize, planted in rows, and cultivated with the horse hoe; and roots may be advantageously sown between the rows of these plants when all the operations belonging to their cultivation have been performed. A field of vetches will produce, first, vetches to be mown while green; then black wheat, which may also be mown while green, and which is in general perfectly successful; or turnips, which may be sown equally as soon, and which will fully repay the expenses of their cultivation: sometimes vetches are sown twice in close succession for the purpose of being mown while green.

7. If in a long rotation it is found necessary to manure the land twice, the second amelioration is never applied to a crop of grain, but to one of some other kind; and then the preference is always given to a crop which may be mown while green, because the vegetation will never be so great, and the weeds which germinate and vegetate amongst it will never materially injure the crop. The ploughing which is bestowed on the ground immediately after the removal of this crop, mixes and incorporates the manure with the soil, and the former is thus deprived of that degree of fermenting warmth which tends so much to accelerate the vegetation of young wheat plants, and too often to lay them.

8. This system of cultivation does not require that one half of the fields shall be devoted to the purpose of raising fodder for cattle; but, as must be evident from what has already been said, merely that one half of

divisions shall be devoted to the production of grain crops. The farmer is perfectly at liberty to cultivate all or any kind of products for sale on the remaining portions; and, provided he has a sufficiency of manure, there is nothing to prevent him from cultivating those plants or vegetables which are likely to prove most profitable. But, in order to secure that abundance of manure which, when combined with skilful cultivation, is capable of producing such astonishing effects, it is frequently necessary that the farmer should content himself during the first rotation with a small portion of saleable products, in order to raise a store of future provender for his cattle.

By means of this alternation of crops, the farmer has it in his power either to pasture his cattle on a portion of the fields, or to feed them entirely in the stable. In the former case, the rotation with pasturage is brought to its highest degree of perfection; and the latter affords undeniable advantages in those positions and circumstances which render stall-feeding difficult. The highest possible degree of produce can only be obtained from the soil by means of this system; but it is doubtful whether the highest amount of profit is thus obtained from the labour which is applied and the capital which is invested.

We will next proceed to examine the system of

### *Alternate Cultivation, accompanied by a suitable Succession of Crops and Pasturage.*

In this mode of cultivation, one portion of the land is laid down as pasture for cattle, and sometimes for sheep only.. But the soil is used for this purpose while in very good condition; and in order that it may produce the desired effect, it is sown with the seeds of those plants which are best fitted for pasturage; and thus it is made to yield a very rich and abundant herbage, which is capable of either maintaining a greater number of cattle, or of feeding those which are kept on a smaller space. Besides this advantage, other kinds of fodder are likewise cultivated, either for the purpose of feeding a few or all the cattle in the stalls during the summer, or of feeding them conjointly in the stalls and on the pastures, so that it may never be necessary to turn the animals on the pastures too early in the spring, or to over stock them.

This system of cultivation is never profitable unless the rotation comprehends at least eight years. If the cultivation of grain be not much restricted, and if one division is set aside for the growth of fodder, the land does not bear herbage for a sufficient length of time to allow the realization of all the advantages which might be expected to be derived from it. Excepting in small farms on which stall-feeding is always more profitable than pasturage, I would alter the period allowed for the rotation from six or seven to twelve or fourteen years, which numbers would render the transition far from difficult.

Eight is the smallest number of divisions which I consider to be suitable to this species of cultivation; and I should recommend the following rotations (this mark ** will denote the times when it will be necessary to bestow a complete amelioration, and this one * will mark the period when a moderate manuring will be sufficient):—

1.** *a* Beans sown in lines............ or *b** Potatoes.
2. *a* Autumnal corn ............... .. *b* Spring grain.
3. *a* Clover for mowing ............ .. *b* Clover for mowing.
4. *a* Spring grains ............... .. *b* Autumnal corn.
5.* *a* Peas ...................... .. *b** Vetches.
6. *a* Autumnal grain ............. .. *b* Autumnal soil.
7. and 8. Pasturage, with white clover and grasses.

1. Oats on the broken up pasture.. or *b***Potatoes.
2.** *a* Beans in lines ............... .. *b* Spring corn.
3. *a* Autumnal corn .............. .. *b** Peas.
4.* *a* Vetches..................... .. *b* Autumnal corn.
5. *a* Spring corn.
6. *a* Clover for mowing.
7. Pasturage.

In nine-crop divisions:—

1. Oats on the broken pasturage.
2.** Weeded crops sown in lines.
3. Barley.
4. Clover.
5. Autumnal corn.
6.* Peas and vetches.
7. Autumnal corn.
8. }
9. } Pasturage sown with grasses.

Or:—

1. Oats on the broken up pasturage.
2.** Weeded crops.
3. Barley.
4.* Peas and vetches.
5. Autumnal corn.
6. Clover for mowing.
7. }
8. } Pasturage.
9. }

In ten-crop divisions:—

1. Oats on the broken up pasturage.
2.** Weeded crops.
3. Barley.
4. Clover for mowing.
5. Autumnal corn.
6.* Peas and vetches.
7. Autumnal corn.
8.
9. Gramineous plants sown for pasturage.
10.

Should the farmer wish to have more clover and less pasturage, he can allow the former to remain for two years and deduct one year from the period allotted to pasturage.

Or the rotation may be thus arranged:—

1.** Cabbages and peas.
2. Autumnal corn.
3.* Weeded crops.
4. Barley.
5. Clover.
6. Autumnal corn.
7. Spring corn.
8.
9. Pasturage.
10.

Or, if the soil is of a sandy nature, it may be thus arranged:—

1. Black wheat.
2. Rye.
3.** Weeded crops.
4. Oats.
5. Spurvey.
6. Rye.
7.
8.
9. Pasturage.
10.

In eleven divisions:—

1. Oats.
2.** Weeded crops.
3. Barley.
4. Clover.
5. Autumnal corn.
6. Vetches to be mown while green.
7.** Cabbages.
8. Autumnal corn.
9.
10. Pasturage.
11.

Cabbage should never be cultivated unless there is a plentiful supply of manure. Whenever this is not the case, the vetches must be succeeded by a crop of autumnal corn, and four years devoted to pasturage.

Or, the rotation may be arranged as follows:—

1.** Cabbage.
2. Autumnal corn.
3.* Weeded crops.
4. Barley.
5. Clover.
6. Autumnal corn.
7.* Peas and vetches.
8. Autumnal and spring corn.
9.
10. Pasturage.
11. Pasturage until the middle of summer.

When divided into twelve years:—

1. Vetches.
2. Autumnal corn.
3. Clover for mowing.
4. Oats.
5.** Weeded crops.
6. Barley.
7.* Peas.
8. Autumnal corn.
9.
10.
11. Pasturage.
12.

In this rotation, likewise, the pasturage in the twelfth year may be broken up about the middle of summer;

cabbages may also be substituted for vetches in No. 1, if there is a sufficiency of manure.

Or:—

1. Vetches.
2. Autumnal corn.
3.** Weeded crops.
4. Barley.
5. Peas.
6. Autumnal corn.
7. Beans weeded.
8. Oats.
9. Clover for mowing.
10\.
11. Pasturage.
12\.

When there are fourteen divisions:—

1.** Cabbages.
2. Autumnal corn.
3. Peas.
4. Autumnal corn.
5.** Weeded crops.
6. Barley.
7. Clover.
8. Clover.
9. Autumnal corn.
10. Oats.
11\.
12\.
13. Pasturage.
14\.

Or, the rotation may proceed thus:—

1. Oats.
2.** Weeded crops.
3. Barley.
4. Clover.
5. Clover.
6. Autumnal corn.
7. Peas.
8. Barley.
9.** Beans weeded.
10. Wheat.
11\.
12\.
13. Pasturage.
14\.

Rotations comprising a greater number of years may be considered merely as repetitions of those already mentioned, and only attended with various modifications. I shall only subjoin a rotation of twenty-four years, which has actually been introduced on an estate on which three dairies and the fields appertaining to them are contiguous, so that these are all included in one whole; this rotation is practised on an extent of 3,000 acres, and is as follows:—

1.** Cabbages.
2. Autumnal corn.
3.* Potatoes.
4. Barley.
5. Clover for mowing.
6. Ditto, ditto.
7. Autumnal corn.
8.* Peas and vetches.
9. Autumnal corn.
10\.
11. Pasturage.
12\.
13. Oats.
14.** Beans weeded.
15. Autumnal corn.
16. Clover for mowing.
17. Autumnal corn.
18. Vetches for mowing and then roots.
19. Spring corn.
20. Peas.
21. Autumnal corn.
22. Clover for pasturage.
23. Pasturage.
24. Pasturage of spring to be broken up early, in order to allow time for planting cabbages.

If, in this rotation, it should be necessary to fallow the ground completely or to manure it with marl, it should be done as much as possible on those divisions which are least in use, and even then some kind of product may be derived from the soil both in spring and in autumn; as, for example, a crop of vetches to be mown while green, or a crop of radishes.

The rotation of which we are about to speak, is peculiarly adapted for keeping large flocks of sheep, to which the pasturage is devoted, while the cattle are for the most part fed in the stalls.

### *Alternate Cultivation—with Stall-Feeding of the Cattle.*

The following is one of the distinguishing characteristics of this system of cultivation: the cattle are fed all the year round on fodder, cut expressly for that purpose, and are never turned out to pasture except towards the end of the summer. They are fed in stalls, or in courts or yards constructed for the purpose, or in strong moveable enclosures, the situation of which is changed every year, and placed near to those divisions of land which are intended to furnish the principal part of the fodder. In some points of view, the practice so much esteemed in some countries may be comprehended under this head, namely, giving the cattle a good feed in the stable before they are turned out to pasture.

This is not the place for entering into any arguments relative to the advantages of the one of these systems over the other, all that we have to do at present is to consider the relation in which they stand to cultivation in general.

The following are some of the principal advantages attendant on this species of cultivation.

1. The same, or even a larger, number of cattle can be maintained on the produce of a much smaller extent of ground.

(*a*) Because, under this system, the fields receive a preparation which fits them for the production of those vegetables which are used as fodder. Nor is the propagation of herbage left to nature alone: the farmer sows and plants the seeds of those plants which are best adapted for the nourishment of cattle, and which are most likely to succeed in the soil which is destined to receive them. By this means the generative powers of nature are brought into full action, and the soil is made to produce an incomparably greater quantity of fodder than could be obtained from it under any other course of cultivation.

(*b*) Because this species of cultivation allows the plants destined for herbage to attain their highest state of vegetation, and to reach that point of development at which they yield the utmost amount of produce of which they are capable, both as regards quantity and quality. In fact, the development and growth of most of the plants destined for fodder progressively increases to a certain point, and this increase is greater in proportion as they approach the highest degree of perfection which they can attain : in the early part of their existence, the vegetation is very weak for a time, but, as the plant becomes more and more developed, the vegetation is accelerated; but when, as is the case on pasture lands, they are not suffered to attain their full maturity, the utmost amount of produce cannot be derived from them. The plant, however, ceases to grow as soon as it has flowered; and in proportion as the seed is developed, the stalk and leaves lose some part of the nutritive juices which they previously contained. It is therefore evident that it is only by mowing that they can be made to yield the highest advantages, as, when this is performed at the proper season, the plant not having been weakened by the formation of seeds, will frequently put forth new shoots, which, if allowed to remain, may attain an equal degree of perfection.

(*c*) Because, in this system, the plants are not crushed, destroyed, and trodden down, or their vegetation retarded by the pressure of the feet of the cattle.

Experience proves that by this method one half of a given extent of land may be made to yield an equally abundant and rich provender as that which, under other circumstances, would be derived from the whole; and thus one-half will be left at liberty to be applied to any other purpose, and yet an equal if not a larger number of animals may be profitably kept.

2. Cattle are kept principally for the dung which they yield, and it is only under this system that it is possible to collect and obtain the utmost quantity of manure.

In every system of cultivation wherein the cattle are fed on the pastures, the principal part of the dung voided by them during the summer is scattered abroad. Those excrements which fall on the herbage are totally lost for all purposes of cultivation, and they appear to afford but little benefit to those spots on which they fall; for the dung which is voided over old pasture grounds on which cattle constantly graze, does not appear to augment the vegetation of the herbage in an equal proportion. It frequently produces no other effect on the plants on which it falls than giving it a disagreeable taste, which disgusts the cattle; and the knowledge of this fact frequently leads the herdsmen to collect the lumps, and appropriate them to their own use. The loss is not so great where the dung is voided over fields laid down to rest; but even then the principal part of it is evaporated, and the land does not derive one-tenth part of the advantage which would accrue to it if the same quantity of manure was carefully collected, prepared, and properly mingled with the soil.

3. In cultivation combined with stall-feeding of cattle, it is much easier to make crops of fodder and of grain succeed each other alternately, than under any other system; and, therefore, all the numerous advantages that attend this union and alternation of products, are better attained. It admits those plants which are destined for fodder to be cultivated in such an order and succession as shall offer the least possible degree of interruption to the succession of crops destined for sale, and particularly to the corn crops; and as the former are a preparation for the latter, and are principally intended to clean the soil and render it loose and fertile, they render the operation of fallowing altogether superfluous, and form a very advantageous substitute.

4. This system likewise furnishes the cattle with a

regular and abundant supply of succulent and agreeable food all the year round, provided the proportion and succession of the fodder crops is properly regulated. Consequently, the health and strength of the animals is preserved and sustained, and they are thus rendered more capable of work, and made to yield a higher amount of profit. When cattle are fed on pastures, this will never be the case, unless the herbage is uncommonly rich and abundant, on account of the inequality which is frequently found to exist in the fertility of pastures in different years, whether distant or successive.

Where stall-feeding is practised, the excess of fodder which the cattle do not consume in one year may be reserved for some other season which is less fertile; besides, it is very beneficial to the cattle to have dry food mingled with their green meat.

By means of this system, therefore, it is not only possible always to feed the cattle regularly, but also to preserve a steady equilibrium in all the other parts of the rural economy; since not only an average quantity of manure may be reckoned upon every year, but the farmer may likewise consider that, when he has a superabundance of fodder, he can always increase the number of his live stock if he thinks proper, or deems that such a course will tend to augment either his profits or the quantity of manure likely to be derived.

5. Lastly, it has not only been proved by the results of innumerable experiments, that cattle can be maintained in perfect health by means of stall-feeding, especially if occasionally, when they are taken out to water or to bathe, they are allowed some exercise in the open air, but also that they are thus preserved from several very dangerous diseases to which animals that are depastured are liable, such as inflammation of the spleen, &c.; and that they are far less disposed to catch infectious diseases; so much indeed, is this the case, that in some countries where this system of feeding is generally established it seldom happens that any disease spreads very

far. At any rate, it is evident that, at such a period, this mode of feeding has decided advantages over the grazing of cattle in open fields or pasture grounds, even if it is not superior to pasturing them in enclosures.

It is evident that the objections alleged against stall-feeding and the consequent perfection of cultivation, are not tenable if separately considered; nevertheless it cannot be denied that, when united together, they may, under certain circumstances, render the expediency of the adoption to be very doubtful, and even plead strongly in favour of pasturage when combined with a good rotation. In districts or countries where the details and arrangements connected with stall-feeding are yet unknown, or where the servants, or those charged with the duty of inspecting all the operations and proceedings, are prejudiced against it, this system will require more minute and careful attention than can be bestowed upon it by a person who is at the same time occupied in directing several other branches of rural economy. Previous to the introduction of stall-feeding, it will always be necessary, in order to secure success, to hire men, expressly for that purpose, who are capable of managing it properly.

This system requires a considerably larger *circulating capital,* not so much for itself as for the maintenance of the vigorous cultivation with which it is associated. It therefore appears to be peculiarly suited to those places and circumstances in which, so far from being obliged to derive a great portion of his income from the soil, the agriculturist possesses a surplus on which he can draw whenever occasion requires it; because, if the contrary was the case, he might not always find it easy in a large undertaking to raise the necessary funds for defraying the cost of labour and the other expenses attendant on this system. Wherever the quantity of capital is circumscribed, alternate perfectionated cultivation with pasturage will be found much more advantageous, especially at the commencement, and afterwards it will be much easier to make the transition to stall-feeding. On the other hand, the advantages attendant on this mode of feeding cattle are increased in proportion to the value of the soil, and the tillage and ameliorations which are bestowed upon it.

There is no case in which so little profit is derived from this system as when it is practised on estates composed for the most part of sandy earth, which contains less than twenty-five parts in every hundred of argillaceous clay and mould. Soils of this nature are materially benefited by long periods of what is called "repose, or rest," by being left untilled, and by being pastured by cattle: they thus acquire some degree of consistency, which, however, they would soon entirely lose if they were too frequently ploughed.

Land of this kind is also less suitable for cattle than for pasturing sheep, and for which animals stall-feeding has yet been little introduced. Notwithstanding the abundant manuring which this system enables the farmer to bestow, there is always a great degree of uncertainty attending the cultivation of plants for summer fodder, on account of the occurrence of periods of drought. However sure the farmer may feel of the success of the crops of roots destined for the winter fodder, he never can divest himself of a dread of the failure of the other crops.

A distinction has been made between complete and partial stall-feeding. The latter does not signify the practice which is sometimes met with, that of feeding one half of the animals in the stable while the others are turned out to pasture, but it is giving all the animals one portion of their food in the stable and the rest on pasture grounds.

Many persons have regarded this mode as by far the most profitable manner of feeding cattle, and the more so as the quantity of milk obtained from cows fed in this way is much greater than under any other circumstances. The change in the kind of food is certainly calculated to give the animals a better appetite, and also to stimulate their digestive organs to healthy action. This practice is peculiarly adapted to farms which are contiguous to lands which, either from the dread of inundations or from some other cause, can only be used as pastures, and which, nevertheless, are not sufficiently extensive or fertile to supply the cattle with all the food which they require for their maintenance during the summer.

Stall-feeding may be associated with various systems of cultivation, among which the three following are the principal modes :—

The first and most ancient method of procuring a supply of green provender for the cattle during the summer, consists in devoting certain enclosures or fields to the growth of clover. Pieces of land near to the farm buildings are usually chosen for this purpose ; and these are sown every third year, and not unfrequently in the first year and with the first crop of corn, with clover, which is to be cut while green ; or, where the nature of the soil will admit, with lucern. When this fodder is taken off the land, roots or cabbages are cultivated for one or two years, and sometimes a crop of corn or of some leguminous plant, and then the land is sown anew with fodder-plants. But these enclosures consume a very great quantity of the manure, and without frequent and repeated ameliorations, the clover crops, following so quickly on each other, cannot be made to succeed at all. The principal object of the cultivation of fodder, and of stall-feeding in general—that of procuring the greatest quantity of manure for the whole extent of the fields—is here entirely lost ; and thus the otherwise absurd reproach so often made to the cultivation of green fodder, namely, that it requires more manure than can or ought to be bestowed on it, becomes, in some respects, true. Another consequence of this method is the annihilation of a second advantage attendant on the stall-feeding of cattle, and the consequent cultivation, viz., the alternate succession of green crops with crops of grain on the fields ; a dead fallow must be introduced, or the land will speedily become infested with weeds. It is only when sown on open fields and introduced into the general rotation, that the green crops can fully attain the end for which they were destined, that they will effect a chemical amelioration in the soil by means of the manure which is applied to them, and a mechanical amelioration in it by means of the loosening and cleansing tendency.

The cultivation of plants for fodder on separate enclosures can therefore only be regarded as a very injudicious if not a pernicious means of procuring some additional provender for the cattle, on farms submitted to the system of fallows, or of non-perfectionated alternate cultivation with pasturage; and it is utterly opposed to the end which stall-feeding, as it is generally conducted, has in view. An enclosure of inconsiderable extent situated near the farm buildings, and sown with perennial fodder plants, or with lucern or grasses for mowing, may, nevertheless, occasionally be found useful, and may tend to facilitate the complete stall-feeding of cattle by furnishing a supply of provender at periods when it could not be obtained elsewhere.

The second method of obtaining fodder by cultivation consists in introducing the crops into the triennial rotation in the place of the fallow. We have already spoken of this method, which was principally propagated by Schubart, and have stated the advantages which may be expected from it, and the evils it possibly may produce. This mode does not deprive the soil of any portion of fertility; but, on the contrary, when the clover is vigorous, thick, and free from weeds, it communicates additional succulency and nutrition to the land. But the clover crop can only be expected to possess these three advantages under the triennial rotation, where it has been sown on peculiarly fertile ground, and where it is only sown once in nine years in the same place. The occasional failure and the frequent scantiness of the crops on estates which do not possess that additional extent of meadow land which is absolutely necessary to secure an adequate maintenance for the cattle throughout the summer and winter, has caused this method to be everywhere abandoned except in the most fertile districts; and the system of stall-feeding has, in consequence, fallen into disuse.

Where the failure of the clover has been attributable to accidents, many industrious and persevering agriculturists have endeavoured to remedy the evil by sowing vetches, or a mixture of various plants which may be mown while green, or by cutting down their peas to feed the cattle; but where this failure has repeatedly occurred, and has evidently been occasioned by some fault in the system itself, they have found themselves compelled to renounce it altogether: some few farmers have persisted in this mode of cultivation until their land became completely choked with weeds.

The third method, and the only one which has hitherto appeared to be really successful, or on which stall-feeding can be based with any degree of certainty, is that of *alternate perfectionated cultivation*, in which clover is always sown on a soil that has been deeply ploughed, and still retains all the fertility produced by the recent amelioration, and where it is possible to procure an auxiliary by the cultivation of other plants, as fodder for the middle of summer, antumn, and winter, so that the cattle may receive rich, abundant, and succulent food in every season of the year. We have already given a detailed account of the principles on which this system is founded; and as we shall have occasion to allude to it again when treating of the cultivation of plants and the feeding of cattle, we shall not enlarge further upon it at present.

We shall here confine ourselves to an enumeration of those rotations which, taking into consideration the number of divisions of the land, produce the greatest quantity of fodder, and, consequently, of manure, and with the sacrifice of the least possible portion of the crops destined for sale.

We will suppose that the soil consists of argillaceous earth, which contains at least thirty parts in a hundred of alumine and humus, and at most seventy parts of silex in a hundred; such a soil as in wheat-land would be termed second-rate, in barley-land first and second-rate, or among good soils would be classed as average or middling land. Clover certainly will also succeed on a lighter soil, which contains from twenty-five to thirty parts in a hundred of alumine, provided that the land has been properly manured; but the success is so very uncertain in dry years that no reliance can be placed upon it, where all the fields or even where only some of the divisions are composed of land of so light a nature; on estates of this kind, therefore, as we have already said, alternate perfectionated cultivation is always less casual. In making choice of the crops which are to form parts of these rotations, attention must always be paid to the more or less argillaceous nature of the soil, as well as to the calcareous matter and to the humus which has been more recently added to it. We shall give some directions with regard to the manner in which these considerations ought to influence the choice of the rotation:—

### *Four Crop Divisions.*

1.** Weeded crops, and in this number beans sown in rows may be included.
2. Barley.
3. Clover.
4. Rye or wheat.

From some incomprehensible misconception, this rotation, which is practised by a great number of English agriculturists, and which I used formerly to follow upon a small farm of my own, has been regarded by many persons as the only form of alternate cultivation. It is, however, suitable to estates of a very limited extent; on large properties it is found advantageous to increase the number of divisions.

### *Five Crop Divisions.*

After the autumnal corn, a crop of oats may be obtained from the land without causing any bad effects, the succeeding weeded crop being intended to clear and clean the ground. In the experiments which I have made with regard to the rotation, I find that oats, when compared with other crops, are not sufficiently profitable to induce me to persevere in cultivating them. In those places where the great object in view is to secure as large a proportion of fodder for the cattle as possible, the clover may be suffered to remain upon the ground for two years.

### *Six Crop Divisions.*

The four first follow in the same order as those mentioned above.

5.* Peas; which, if necessary, may be succeeded by vetches to be mown while green.
6. Rye.

In these rotations I usually prefer autumnal corn to spring corn; the produce of the former being more to be depended upon, the crop yielding a much greater quantity of straw, and the operation of sowing—especially if carried into effect with the proper instruments—being much more easily accomplished after the fallow crops. Should any unforseen occurrence prevent the whole of the land from being sown in the autumn, it is always possible to sow the remaining part with spring corn.

### *Seven Crop Divisions.*

Here also a crop of oats may be obtained after the rye crop. In the greater number of cases, however, those persons who wish to preserve the fertility of their land, and also to establish the stall-feeding of their cattle upon a secure foundation, will do well to allow the clover to remain upon the ground for two years, and content themselves with two crops of autumnal grain, one of spring corn, and the half or two-thirds of a division sown with peas. Here, and in every case where a superabundance of root crops is found in the first division, beans sown in rows and tilled with the hoe may be substituted; and after these have received the last tillage, radishes may be sown with advantage between the rows; and these latter may also be sown after vetches which have been mown while green; but they must be removed very early, in order to make way for the autumnal corn.

### *Eight Crop Divisions.*

1.** Weeded root crops.
2. Barley.
3. Clover.
4. Oats.
5.* Peas.
6. Rye.
7. Vetches.
8. Rye.

Or :—

1.** Weeded root crops.
2. Barley.
3. Clover.
4. Clover.
5. Rye.
6.* Peas and vetches.
7. Rye.
8. Oats.

### *Nine Crop Divisions.*

1.** Weeded root crops.
2. Barley.
3 and 4. Clover.
5. Rye.
6.* Peas.
7. Barley.
8. Vetches.
9. Rye.

### *Ten Crop Divisions.*

1.** Weeded root crops.
2. Barley.
3. Clover.
4. Ditto, broken up after the first cutting.
5.* Cabbages.
6. Wheat.
7. Peas.
8. Rye.
9.* Vetches to be mown while green
10. Rye.

In order to cultivate cabbages, which crop is peculiarly adapted to this rotation, the farmer must have an abundance of manure at his disposal; but with such a succession of crops he will soon be possessed of that powerful auxiliary to his cultivation.

### *Eleven Crop Divisions.*

The same as the foregoing, with the addition of a crop of oats after the rye.

### *Twelve Crop Divisions.*

1.** Weeded root crops.
2. Barley.
3. Clover.
4. Clover.
5. Clover broken up after the first cutting.
6.* Cabbages.
7. Wheat.
8. Peas and vetches.
9. Rye.
10.* Beans sown in rows, and radishes.
11. Barley.
12. Rye.

Or, should it be deemed expedient to endeavour to obtain a still greater quantity of those products which find a ready and profitable sale, the farmer may, if he finds himself in possession of a sufficiency of manure, break up the clover on the fourth division immediately after the first cutting, and arrange the latter part of the rotation as follows :—*

5.* Cabbages.
6. Wheat.
7. Vetches.
8. Rye.
9.** Tobacco.
10. Wheat.
11. Beans, succeeded by radishes.
12. Barley.

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* The temperature of the north of Germany, for which these rotations are particularly adapted, is too unfavourable to lucerne to admit of the author's introducing that plant into his successions of crops; but such is not the case

## *The Transition from one Rotation to another.*

No prudent agriculturist will exchange his present system of cultivation for another even a better one, without maturely weighing and considering all the cir-

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in France, for lucerne always thrives wonderfully well there; and when it is cultivated on land that has been properly manured, deeply and carefully ploughed, and thoroughly cleaned from weeds, and which is not of too argillaceous a nature, nor too much disposed to become dry and hard, but has a tendency to retain water and moisture, this plant will prove the most advantageous of all those which are cultivated for the purpose of feeding cattle. Without any wish to anticipate those details which properly belong to that portion of the work which treats of the cultivation of vegetables, I must, nevertheless, here observe, that lucerne will yield plentiful crops for four, six, eight, and sometimes ten years, according to the care bestowed upon the sowing and the treatment of it; but the finest and most abundant crop is produced in the third year; from that time it becomes more or less mixed with weeds, which, in the end, entirely choke it. In places where there is a great extent of meadow land, and, consequently, where the wind scatters the seed of gramineous plants in all directions, the lucerne becomes deteriorated much sooner than in those situations where the greater part of the land by which it is surrounded is submitted to the action of the plough and to a good rotation. But it sometimes happens that the plants which thus become mingled with the lucerne are so well adapted for fodder and yield such a plentiful and useful produce, that it still continues to be advantageous to suffer the lucerne to remain on the ground.

The propriety and utility of cultivating old lucerne ground, will depend, in a great measure, upon local considerations, and upon the relative advantages which the soil might be made to produce in each of these occupations; but if the lucerne has been suffered to remain upon the ground until the plants perish of their own accord, it becomes absolutely indispensable that the soil should be thoroughly and abundantly manured, carefully cleared of weeds, and also allowed a very considerable interval of repose; without the fulfilment of these conditions there will be every reason to fear that the lucerne will not succeed when sown afresh.

In districts where the soil is easily tilled, and where labourers are not scarce or wages expensive, it appears to be advantageous to allow the lucerne to remain on the ground for five years only, and then to plough it up and sow autumnal corn, for which, under these circumstances, this plant forms an excellent preparation. After one, or even two consecutive crops of winter cereal plants, which will succeed very well without manuring, and in which it is only necessary to keep the soil free from weeds, a cleaned crop may be made to supervene, such as potatoes or beet-root, which seem to me in this place to succeed better than carrots or ruta-bagas.

I will here give, as an example of this kind of cultivation, the excellent rotation which M. Chas. Pictet has used for some years past. This gentleman is a zealous agriculturist, and one who devotes his whole attention to the study of that science, and to the propagation of new and enlightened views of every portion of it. I extract this rotation from No. 12 of the "Bibliothica Britannica," Dec., 1810, in which work the author describes it in a manner which is at once lucid, instructive and interesting. I must also add, that I have had frequent opportunities of observing the admirable manner in which it acts on an estate cultivated by M. Pictet, at Lancy:—

1. Potatoes, preceded by the ground having been deeply dug up with a spade.
2. Wheat, thoroughly manured with dung spread over the seed in the winter, which improves the surface of the soil and ensures the success of the clover which is sown on it in the spring, and then covered by a long-tined harrow.

cumstances of his situation. We are now about to lay down a few general rules on this head, which will be found applicable to almost every situation and locality.

In the first place, the transition to a more perfect rotation cannot be effected without the outlay of a considerable capital. There certainly are cases in which this end may be attained by the outlay of a large or small sum, but much sooner and more effectually with the former than with the latter, supposing that the director of each undertaking possesses an equal degree of skill. In order to augment the quantity of fodder which is the groundwork of all ameliorations, a temporary sacrifice of some portion of the saleable products must be made; and this can only be done by diminishing the extent of ground sown, and which diminution cannot be compensated by any augmentation of the produce of the remainder; or else by diminishing the allowance of manure, and employing a portion of it in the cultivation of plants for the purpose of feeding cattle. To this must be added the expenses attendant on the necessary increase of live stock, servants, and labourers. It is quite a mistaken

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3. Two cuttings of clover.
4. Wheat, and sometimes roots as a second crop.
5. Potatoes, as in the first year.
6. Wheat, as in the second year, but with this difference, that lucerne is sown instead of clover in the spring.
7 and 8. Lucerne.
9. Lucerne, thoroughly manured during the winter.
10. Lucerne, broken up in the summer.
11. Wheat.
12. Wheat, succeeded by radishes.

This rotation is far from being an expensive one to M. Pictet, and for the following reason. The greater part of the potatoes are cultivated by the poor people in the neighbourhood, who, in return, receive one half of the produce, which serves to prevent them from suffering from want. Thus, M. Pictet is the benefactor of a great number of poor families, at the same time that he derives his own share of benefit. I would advise all my readers to peruse the account which this gentleman himself gives of his rotation, and only regret that I cannot transcribe the whole of it here. Sainfoin ought not to be forgotten: this plant is calculated as well as lucerne for alternate rotations. The produce, certainly, is not so abundant as the other; but it does not require so much manure, and will flourish on sandy and gravelly soils, where lucerne can never be made to vegetate with any degree of success. Besides the seed of sainfoin being much more expensive than that of lucerne, it is scarcely worth while to sow fields with this plant merely for a limited number of years.—French Trans.

notion, however, to reckon these outlays as so many sacrifices: they are neither more nor less than sums advanced for the purpose of communicating fresh vigour and greater activity to all the operations; and, unless some extraordinary ill-fortune attends the agriculturist, the capital thus expended will, in a short time, be repaid with interest. Nevertheless, it is perfectly useless for any one who cannot command the necessary funds to attempt this transition, at least with any chance of success.

The requisite amount of capital, as we have already said, varies in different cases. If the agriculturist wishes to proceed with tolerable rapidity, and, at the same time, with all requisite circumspection, he must possess a capital at least double in amount of the net produce which the estate formerly yielded. He must not be in too great haste to increase the number of his live stock; neither must he make any changes, alterations, or additions to his farm buildings, which are not absolutely and palpably necessary.

It is impossible to effect any profitable modification in the cultivation of an estate without the outlay of a certain capital; wherever such a thing appears to have been done, it has either been effected by a continued system of economy carried through every branch of the farm management, or by means of the application of additional labour. The want of capital, or at least of the will to employ it in furtherance of this end, is the great cause of most of the failures in enterprises of this nature. It is of the greatest importance that all persons should be impressed with a conviction of this truth, and that those prejudices which still exist against it should be wholly removed.

Another absolutely essential preliminary is that the farmer shall be sole and absolute master of all his land, free to act, and unfettered by any trammels and servitudes; and whenever the contrary is the case, his first step must be to obtain an exemption from all restrictions which might confine his freedom of action.

The process of effecting a transition from a triennial rotation with fallowing to an alternate rotation associated with stall-feeding, on an estate already divided, is not attended with difficulty if each of the fields have been regularly ameliorated. But in those places where it has only been possible to manure thoroughly a portion of the arable land, and where the remainder has been but slightly or not at all ameliorated, much greater obstacles are met with, nor can it be expected that this object can be effected without the aid of extraneous means. As it is not, however, absolutely indispensable in this case that the divisions should be contiguous and that the numbers should follow each other in regular succession, as in all rotations that are associated with pasturage, every thing will be gradually got into the proper order. If, as is generally the case, the lands which were not comprehended in the rôtation lie at some distance and contiguous to each other, it will generally be more advantageous to adopt two or more courses of cropping, or to divide the arable land into exterior and interior divisions, and in the first place to ameliorate the latter and then wait until the fertility of these fields and the abundance of manure produced by them, shall make it easy to bestow some amelioration on the former. If this mode cannot be adopted, the manuring of the principal divisions will be delayed, and it will be necessary to abstain for a longer period from the cultivation of vegetables for sale.

Should the position and form of the fields appear to render it necessary, matters may be so arranged that each fertile division shall have a supplementary portion of poor and ill-conditioned land, even though it should not be contiguous. This additional part must be gradually amended and improved, in the course of cultivation, until it becomes equally good with any of the other portions. In order to effect this result, it must be allowed a longer period of repose, and only occasionally made to produce a crop of the same kind as that borne by the principal division.

In effecting this transition from a rotation with fallows to the alternate system, the principal object to be kept in view is the speedy augmentation of the quantity of fodder in order to obtain a larger supply of manure. This can only be done by diminishing the grain crops: but the retrenchment must not be made on the autumnal corn, or in the manure which ought to be devoted to them; because that crop not only yields a larger produce in grain, but also furnishes a greater quantity of straw.

## SECTION III.

## AGRONOMY;

### OR, A TREATISE ON THE CONSTITUENT PARTS AND PHYSICAL PROPERTIES OF THE SOIL, AND THE BEST METHOD OF ACQUIRING A KNOWLEDGE OF THE DIFFERENT EARTHS, AND ASCERTAINING THEIR VALUE.

**"What may not enlightened citizens accomplish, who have discarded the false and bustling pleasures of towns, and, carrying into the country the knowledge they may have acquired, apply to agriculture the rich and varied assistance of the physical sciences!"—FOURCROY.**

The soil bears the same relation to agricultural industry as primitive substances do to manufactures in general. The agriculturist endeavours to find land that shall unite all the qualities he requires, with the same anxiety and care that a manufacturer bestows on the selection of the materials best adapted for his purpose. Each of these persons exercises all possible judgment in forming a just estimate of the value of the article which he is about to purchase or obtain possession of, in order to avoid giving more value for it than it is worth. Each of them, also, when he has obtained the substance or matter which he requires to work with, examines its merits or demerits more narrowly, gives to each of its parts that destination for which it appears to be best adapted, and by means of which he may derive the greatest possible amount of profit both from the substance itself and from the labour which is applied to it.

The manufacturer loses both time and money when he attempts to fabricate fine cloth from coarse or jagged wool, and lessens the value of the materials when he endeavours to make coarse cloths from superfine wool. He must, therefore, divide and arrange all his wools according to their various degrees of fineness; and in order to be able to do so properly, he will require much more experience and a far greater knowledge of the subject than is necessary to assist him in the comparatively simple act of making his purchases. In the same way, the agriculturist must not content himself with understanding the directions given in a previous section of this work for the choice and purchase of an estate, if he would derive the most satisfactory amount of profit, both from the soil which he has to work on and from the labour that he applies to it; if such be his aim, it can only be effected by means of a judicious selection of products, based upon a thorough knowledge and just appreciation of the nature and properties of the soil in which they are to be sown.

The seeds, roots, and germs furnished by nature are to the agriculturist what the designs and models fashioned by art are to the manufacturer. The principal aim and study of the farmer ought to be to allot to each of these seeds the soil which is most proper for it, and to bestow on that soil the species of cultivation best adapted to its nature; and the more thoroughly he has made himself acquainted with the properties of the land he has to work on, the better will he be able to fulfil his task.

But a just appreciation of the nature and properties of the soil can only be founded upon sound notions of chemistry and of physics. Although practical knowledge acquired from long experience may be sufficient to enable persons to recognise and appreciate certain particular kinds of land, yet it can never be applied generally to all varieties; experience with respect to one kind would only lead to error, if the results deduced from it were applied indiscriminately to all others, many of which are of a totally different nature, although perhaps apparently the same to one whose knowledge is merely superficial, and not based on science and on a careful study of the subject.

We shall now, therefore, enter into a minute examination of the different kinds of land, taking for our guidance those discoveries in natural philosophy which have latterly thrown so much light upon this subject. So short a period has elapsed since the united attention of agriculturists and naturalists has been seriously directed to this point, that there, doubtless, still remains a wide field for useful investigation, and a vast number of points which require to be better understood; but the knowledge which we have already obtained is sufficient to enable us to form more just ideas on many subjects, and to avoid former errors; and, with study and perseverance, there is little doubt that we shall speedily arrive at that precision and exactness which is so desirable to be attained. In order that we may be able to profit by the experience and discoveries of learned men, it is highly necessary that we should enter the domains of natural history, and endeavour to acquire clear and distinct notions of all the constituent parts of the soil, and of their properties; and as these considerations will lead us to the theory of manures, or of the chemical amelioration of the soil, they will prepare us to enter on that subject when it comes before us.

The surface of our planet, being composed of that loose friable matter which we call the *soil*, or, in other words, the *earth*, is an assemblage and combination of a variety of heterogeneous substances. In common language, we call this mixture "earth;" but it comprises matters which would not be classed under that denomination by any chemist or natural philosopher, though the greater part of it does consist of earths properly so called. The constituent parts of this mixture are the earths *silica, alumina, lime,* and sometimes *magnesia;* portions of *iron* and other elementary substances are also found in it, but these latter are always in smaller proportions than the earths. Besides these simple substances, fertile land contains an exceedingly compound matter, which, on account of the pulverulent form, has been called *mould, vegetable mould, vegeto-animal earth,* &c.; and which differs so materially from earths properly so called, that it ought never to be confounded with them. In order to distinguish it from the primitive earths, we have thought proper to designate it by the Latin word "*humus,*" which we shall henceforth use exclusively in this sense.

The following is one of the principal distinctions between *earths* and *humus.* That, as yet, no agent has been discovered by means of which the former can be decomposed; they appear to be immutable, and cannot be destroyed or essentially changed by any known power in organized nature. The *humus,* on the contrary, is very susceptible of decomposition; it is a matter produced solely by animal and vegetable life, and can be changed and destroyed in itself and by itself, and particularly by the action of exterior bodies. It is reproduced upon the surface of our soil by organic action, and consequently at different periods; and is found even in the same place to vary in quantity as well as in quality.

We will commence by considering those immutable earths which form the basis of the soil, and which are on this account termed "elementary earths;" we will, in the first place, consider them generally, then subsequently in their pure state, and lastly under all those combinations and mixtures in which they most frequently occur. From the position in which these earths are found, being mingled together on the surface of our globe, it appears probable that they did not originally exist in the pulverized state in which we now find them, but rather that the surface once consisted of a solid mass of enormous mountains and valleys, somewhat similar to those which, by the aid of good astronomical instruments, we can trace on the surface of the moon. This solid mass has been gradually loosened and worn away by the action of fire, air, and water. It is well known that lands situated above the level of the sea attract, in proportion to their magnitude, a larger portion of that aqueous vapour which the heated atmosphere continually absorbs from the surface of seas and lakes; by this means the higher regions become permanent reservoirs of water, which occasionally breaks the limits, rushes down the declivities with great velocity, irrigating the valleys and plains below, and carrying with it fragments of earth, rock, and stones of all sizes, which are deposited at the bottom, and successive layers of earth are thus formed. There cannot indeed be a shadow of doubt that the strata of earth which we meet with, especially in countries bordering upon mountains, have been produced and transported there by inundations and torrents, and by the constant action of water; we do not mean to assert that they have been formed at once, but that they have been the work of time, and of the depositions of repeated inundations. One fact which appears to confirm this supposition is, the circumstance of these strata being seldom or never deposited according to their specific gravity, but usually alternating in a totally opposite manner.

The motive which principally induces us to dwell on this subject is our sense of the vast importance which a knowledge of it may be to an agriculturist, as enabling him to discover springs and subterraneous water-courses, to conduct the operations of draining, mining, and digging in search of valuable earths or stones, as marl, lime, coals, &c., of all which substances we shall presently have occasion to speak.

On plains and flat surfaces the layers of earth are generally found to be deposited in a horizontal or slightly inclined position, very similar to those strata which we see formed by the depositions of water. Sometimes these layers extend, in one uniform thickness and similar composition, for an immense distance, so that they appear to have been gradually deposited over the whole surface one after another by repeated general inundations.

At other times they form a kind of bank, thrown up, as it were, at different periods by currents of water, or are forced into the clefts or sinuosities of the rocks in jets or veins; they are also frequently found heaped irregularly together, forming a promiscuous mass of earth and stones, which has every appearance of having been torn up and thrown together by some convulsion of nature.*

In the neighbourhood of mountains of the second order, and indeed in all mountainous countries, numerous irregularities are perceptible. The layers of earth and stone are sometimes found in a horizontal position, but as they approach the heights they assume a different direction, being now oblique, now parallel with the surface; and sometimes the oblique layers are intersected by vertical ones. Even in this formation, however, a certain degree of order is observable; the perpendicular and oblique layers appear to have been thrown up by some subterraneous power or volcanic action, and torn from the beds on which they formerly reposed.

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* "Rocks," said Davy, "are generally divided by geologists into two grand divisions, distinguished by the names of primary and secondary. The primary rocks are composed of pure crystalline matter, and contain no fragments of other rocks. The secondary rocks, or strata, consist only partly of crystalline matter, contain fragments of other rocks or strata, often abound in the remains of vegetables and marine animals, and sometimes contain the remains of land animals. The number of primary rocks which are commonly observed in nature are eight:—1. *Granite*, composed of quartz, felspar, and mica; when these are arranged in regular layers in the rock it is called *Gneiss*. 2. *Micaceous schist*, composed of quartz and mica. 3. *Sienite*, which consists of hornblende and felspar. 4. *Serpentine*, composed of felspar and resplendent hornblende. 5. *Porphyry*, which consists of felspar. 6. *Granular* marble, or pure carbonate of lime. 7. *Chlorite schist*, a green or grey substance somewhat analagous to mica and felspar. 8. *Quartoze rock*, composed of quartz. The secondary rocks are more numerous than the primary; but twelve varieties include all that are usually found in these islands:—1. *Grauwacke*, which consists of fragments of quartz or chlorite schist, embedded in a cement principally composed of felspar. 2. *Silicious sandstone*, which is composed of fine quartz, or sand united by a silicious cement. 3. *Limestone*, or carbonate of lime, more compact in its texture than in the granular marble, and often abounding in marine exuvia. 4. *Aluminous schist*, or *shale*, consisting of the decomposed materials of different rocks, cemented by a small quantity of ferruginous or silicious matter, and often containing the impressions of vegetables. 5. *Calcareous sandstone*, which is calcareous sand cemented by calcareous matter. 6. *Ironstone*, formed of nearly the same materials as aluminous schist or schale, but containing a much larger quantity of oxide of iron. 7. *Basalt*, or *whinstone*, which consists of felspar and hornblende. 8. *Bituminous*, or common coal. 9. *Gypsum*, or sulphate of lime. 10. *Rocksalt*. 11: *Chalk*, which usually abounds in remains of marine animals, and contains horizontal layers of flints. 12. *Plum-pudding stone*, consisting of pebbles cemented by ferruginous or silicious cement." (*Elem. Agr. Chem.* p. 192.)

Beds of various kinds are met with on the very summits of mountains, which, if sought for on the plains, would be found situated at a considerable depth below the surface. If some particular kind of stone or earth is found at the outlet of an opening, or on the summit of a mountain, we may expect to find the same kind occupying a like situation among the layers on the plains, if we dig deep enough to reach it. But as the profundity at which these beds must be sought for in the plains is in proportion to the elevation of the mountain, it often becomes impossible to reach them at all. It not unfrequently happens that it is necessary to seek for coal, lime, or marl, on the mountains and elevations, although there is not a doubt that the plains contain an equal quantity of these substances. Even on the mountains, these layers of earth usually show themselves on that side towards which they incline, and whence the greater quantity of water oozes, because this fluid carries away with it the superior layers of loose soil.

I imagine that most of my readers are conversant with the elements of chemistry; but we must, nevertheless, enter with some degree of precision into that portion of the science which treats of earths, and which is calculated to enable us to form a just appreciation of the nature and properties of the soil with reference to agriculture in general. In fact, although many writers have latterly discussed this subject in a manner likely to prove conducive to the end in view, yet many portions of it still remain for deeper research, and require to be treated in a manner better adapted to benefit agricultural pursuits than they have yet been; especially as the unexplored portions, left in different places, appear to have given rise to numerous and very serious errors and misunderstandings. A knowledge of this department of science is indispensable to an enlightened agriculturist, for such a knowledge can alone point out to him the causes of the different phenomena which occur in the course of his operations, and afford him a satisfactory explanation of various results which must otherwise appear contradictory. A perfect acquaintance with the earths and their properties also teaches the agriculturist how to derive the greatest possible advantage from those powers which nature has placed at his disposal in the land which he possesses, and where it will be profitable to establish lime-kilns, glass-houses, manufactories of tiles, potteries, &c. Lastly, it is this knowledge only which can afford a sure guidance if he would profit by the extensive means of improving and enriching his land, afforded him by the power of extracting various kinds of earths from the substrata of the earth, and spreading them over the surface. It is for these reasons that I have considered it absolutely necessary to introduce this portion of chemistry here.

Until the middle of the last century, chemists admitted the existence of only one elementary earth which they supposed to be the principal constituent portion of our globe, indestructible in the highest degree, and entering more or less into the composition of all solid bodies. It was not until that time that the difference between *alumina* and *silica* began to be perceived. *Lime* was not included among the number of earths, but regarded as a compound body. But as chemists extended their researches farther into the mineral kingdom, they began to appreciate the principal characteristics which serve to distinguish not only the elementary earths already known, but also several new substances which were included in the class of bodies which do not admit of decomposition.

The previously received opinion, that earth was a tasteless and insipid body and insoluble in water, was abandoned: the theory of one single elementary earth was exploded, and each separate kind regarded as a distinct element.

The word " earth" as denoting a body, or any determinate kind of matter, ought, perhaps, to be altogether banished from the science, or applied to those only which are insipid and insoluble in water; it is not possible to give any satisfactory definition of that substance which chemists call " earth."

*Silica* and *alumina* are the most abundant of all the earths, and, I may also add, whose properties are the best defined. Next to them *lime* is most abundant, and exhibits the most marked characteristics; but it resembles the alkalies more than either of the former, which possess no alkaline nature. *Magnesia*, which was so long confounded with the other earths, has at length been recognized as a distinct substance. It now forms a connecting link between the insoluble earths and the alkalies, and the connection thus formed may, for the present, justify the association of all the natural crude earths in one class. The decomposition of certain mineral products and stony bodies has successively brought to light a number of new simple substances which may all be ranged in the class of earths: some of these are nearly allied to *silica* and *alumina*, and others to the alkalies. A few years ago there was a rage for the discovery of elementary bodies, and, consequently, many chemical products which have since been discovered to be compounds were then set down as simple elements. Most chemists of the present day reckon nine sorts of elementary earths, and of this number five are wholly uninteresting to us, because they are seldom or never found in the form of earths on the surface of our soil.

Since, notwithstanding all the endeavours which have been made, no one has yet succeeded in decomposing the pure earths before mentioned, they must be considered as *simple* or *elementary* bodies. Nevertheless, various phenomena which have been minutely observed, render it no longer doubtful that these are compound substances, since they are formed in organized bodies. Schrader, of Berlin, has proved that gramineous cereales which have been carefully prevented from coming in contact with lime, contained more lime and silica than the seed from which they grew. De Saussure has also found a quantity of lime in the ashes of various kinds of wood which had grown upon a soil absolutely free from that substance, and the same observation has been also made of Einhoff. Vauquelin has shown that the excrements and eggs of chickens contain a much greater quantity of lime than the food given to these birds. Now, since according to the atomic theory, all effects in nature consist in the motion and reciprocal action of substances already existing; it is evident that no body can be produced by natural processes, unless the elements are already in existence. A substance cannot therefore be regarded as simple when the time of the formation can be fixed; it must, on the contrary, be regarded as a compound.*

The earths are indestructible by fire, and they may be exposed to the most violent heat without volatilizing; they are all infusible when exposed separately to the action of heat; neither can they be fused in a fire fed with oxygen gas: but it is a very remarkable fact, that they lose this character when several of them are mixed together. Silica, lime, and alumina are infusible when exposed separately to any degree of heat; but are easily melted when put together in a mass. According to the greater number of experiments, the earths have no affinity for oxygen, and for this reason they are incombustible. Nevertheless, Humboldt has thought that several of them, and particularly alumina, have some affinity for oxygen, even when in a state of perfect purity. Others, again, have denied the truth of this assertion, believing that the affinity in question has no existence unless the earth contains a metallic oxide or some combustible matter. This question, however, is not so important with regard to the art of fertilizing the soil as many persons may imagine, because there is no soil wholly free from metallic oxides and combustible matter.

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* The discoveries of Davy and others have shown that the earths, such as lime and magnesia, are really compound bodies, composed of metals and oxygen. The correctness of the experiments to which M. Thaer alludes, with regard to the supposed power of certain plants and animals *to form* the earths from other substances, we cannot but regard as exceedingly doubtful.

These earths have been found by modern chemists to be compounds of peculiar metals, with oxygen gas, or vital air, in the following proportions :—

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Lime | is composed of | calcium | 71·42 | parts ; | oxygen, | 71·42 | parts. |
| Alumina | „ | aluminum | 56·895 | „ | „ | 43·105 | „ |
| Silica | „ | silicon | 49·888 | „ | „ | 50·112 | „ |
| Magnesia | „ | magnesium | 40· | „ | „ | 60· | „ |

The colour of all the earths is a pure white; the hue which they exhibit in their natural state arises from the admixture of other substances, and chiefly of oxide of iron in various modifications; if that substance did not exist, the surface of our globe would appear perfectly white.

The earths differ from one another in their relations to water. It has already been observed that lime and some other earths, are slightly soluble in water; lime requires 680 times its weight of water to dissolve it completely. Alumina and silica are absolutely insoluble; and as to magnesia, water dissolves an extremely small portion of it, not more than the ten-thousandth part. All earths, however, contract a mechanical union with water, and retain a greater or less portion of it after admixture. We shall designate this property by the term "cohesive attraction;" it not only varies in the different earths, but also in the mixtures formed with them: so that, according to general experience, the quantity of water which these bodies retain when mixed, is not equal to the total amount which would have been retained by them all if the quantity of it present in the mixture had remained separate. Thus, alumina and silica retain a much greater quantity of water when mixed together, than they would have absorbed in a separate state. It is very important to determine the degree of cohesive attraction existing between water and the various kinds of earthy mixtures. In order to accomplish this, a portion of the earth to be examined must be dried, until its weight is no further decreased even by exposure to a temperature equal to that of boiling water. A weighed quantity of it should then be carefully mixed with water, and the mixture poured upon a horse-hair sieve, the weight of which has been previously ascertained; the superabundant water must then be allowed to drop or drain out, and when the water is no longer emitted, the earth should be weighed again, together with the sieve: the weight of the sieve, and that of the earth before it was mixed with water, must then be deducted from the amount of the present weight, and the result will show the quantity of fluid which the earth has absorbed.

As there are many soils which absorb water in larger quantities without permitting it to drain away, and, nevertheless, allow it to evaporate with greater or less facility when they are heated, it is likewise necessary to pay attention to this tendency. In order to determine the degree of cohesive attraction of earth for water in this respect, various kinds of earth must be exposed to the same degree of heat and observations made of the time which each of them takes in becoming perfectly dry.

The earths, and especially alumina, never entirely part with water, but retain a portion of it even when they appear to be perfectly dry; nor can they ever be altogether deprived of it except by exposure to a very high degree of heat, such as that of incandescence or becoming white. In this operation, also, it is necessary to take for a standard a certain degree of temperature at which the drying is carried on.

It is true, that the earths cannot be made to combine with pure nitrogen, carbon, or hydrogen; there are, however, several reasons for believing that they enter into combination with these substances when the latter have previously been united among themselves, and that they absorb and incorporate jointly the organic matter produced by this combination, such as the gases and other results of putrefaction. Various phenomena of vegetation appear to demonstrate this supposition. We shall have occasion, hereafter, to revert to this subject.

The alkaline earths combine with sulphur, both when these substances are fused together and when they are boiled in water; these combinations are, in general, very similar to those formed by the union of sulphur with the alkalies. They formerly received the name of "livers," because they bear a certain resemblance to that viscus (they are the sulphurets of modern chemists). It is probable that these earths form similar combinations with carbon strongly hydrogenated, and particularly with that which contains a small portion of azote—that is to say, with the result of putrefaction; but that these combinations are speedily decomposed at a higher temperature.

All the simple earths, except silica, have a great affinity for acids, and are soluble in them. The acid becomes saturated and neutralized; that is to say, it loses its acid properties; but a similar effect is produced upon the alkaline earths as they lose their peculiar action upon plants and organic matter when combined with acids. The products of these combinations are earthy neutral salts, either more or less soluble, or perfectly insoluble in water. It is chiefly from their action when brought into contact with acids, viz., the formation of earthy salts and the neutralization of the acids, that the earths are distinguished from each other.

But the elementary earths have also an electric affinity or chemical attraction for each other. Many earthy matters and minerals which we meet with in nature, are not merely mixtures, but absolute combinations of earths, in the formation of which the metallic oxides seem to be concerned. Earths may be made to combine chemically by being melted together; but it also appears that this union may be brought about in other ways. According to the experiments of Guyton and Godelin, some earths, as, for example, lime and silica, and alumina and silica, precipitate one another from their solutions—not by the one combining with the acid or alkali in which the other is dissolved, and so separating them—but by entering into combination with the other earth itself. This intimate union of the earths will be of very great scientific importance when the phenomena of the soil shall have been more examined and is better understood.

We shall now proceed to treat of those simple insoluble substances called "silica" and "alumina," in their state of chemical purity, and point out their leading properties, and then go on to examine all the various combinations in which they present themselves to us in nature. Having discussed these matters, and having entered into a more complete examination of the vegetable soil, we shall consider the alkaline earths in their pure state, and, subsequently, the compounds which result from the union of other earths with them. All these subjects will be considered with reference to the use which may be made of them in explaining and teaching the theory of the soil, of manures, and of vegetation, which theory ought to be altogether based upon the physico-chemical doctrine in question.

## SILICA.

This earth derives its name from "*silex*," which, as well as "*quartz*," is almost entirely composed of it; and, in consequence, it was formerly called "*quartz-earth*;" and from the circumstance of forming glass when combined with alkalies, "*vitreous-earth*;" and lastly, since in the opinion of ancient chemists it was the primitive earth, and as it actually does exhibit in an eminent degree all the properties attributed to earths in general, it was called, "*elementary earth*."

Silica occurs in nature more frequently and abundantly than any of the other earths. All hard stones which give out sparks when struck by steel; the enormous mountain masses of granite, porphyry, gneiss, &c., together with the vast oceans of sand in deserts and in plains, are mainly composed of silica.

Generally speaking, there are very few, if any, stones in nature which do not contain more or less of this substance, and there is scarcely a single plant that does not contain and yield it after combustion in the form of ashes. Grasses, in particular, contain large quantities of it; and it is sometimes found crystallized in the epidermis. But, like the other earths, it is rarely found in a state of absolute purity; and quartz itself, of which it forms the greatest part, also contains an admixture of alumina and oxide of iron.

It is only, in fact, by means of artificial processes that silica can be exhibited pure and free from all other mineral substances. It then appears in the form of a very fine white impalpable powder, adhering a little to the fingers, and exhibiting a kind of roughness when pressed or rubbed. It is totally devoid of taste and smell. It undergoes no change when exposed to the action of fire, and neither fuses nor volatilizes, whatever degree of heat may be applied.

Silica has no affinity for water; indeed, without the aid of an intermediate substance, it is impossible to dissolve the smallest portion of it in that fluid. When mixed with water it speedily falls to the bottom, without leaving behind the least portion in solution. There are, nevertheless, certain natural springs which contain silica in solution, but in which the minutest researches of *Bergmann* and *Klaproth* failed to discover the slightest trace of any substance capable of facilitating this combination; and we cannot, therefore, explain the manner by which nature has brought it about. The most remarkable of these phenomena is that of Geizer, in Iceland; a very hot spring which deposits a border of silica around its basin, and forms crystals, stalactites, and incrustations.

The mechanical cohesion between silica and water is also very trifling. When silica is moistened, it does not imbibe the water with avidity; neither does it form a tenacious, ductile, and unctuous paste with that fluid: at the utmost it never retains more than half its weight of water, and it also allows that fluid to evaporate very quickly.

The following is one of the characteristics by which silica is chiefly distinguished from most other bodies; that it is not operated upon or dissolved by any acid, excepting the fluoric. Silica reduced to a fine powder may be boiled with sulphuric, nitric, or muriatic acid, without the smallest portion of it being taken up. It is only when in a state of fusion that borax and phosphoric acid combine with it. Fluoric acid is the only one that dissolves it, forming with it a gaseous compound, and thus possessing the power of carrying the fixed substance with it when evaporated.

The fixed alkalies, on the contrary, whether in their caustic state or combined with carbonic acid, easily unite with silica, and quickly dissolve it. If potassa or soda be fused in contact with silica, it will cause the silica to fuse and enter into combination with it. The product resulting from this combination varies in its nature according to the proportions of the component substances employed. When silica is the predominating ingredient, the resulting compound is the useful substance of glass. The greater the quantity of silica, the more capable is the glass of resisting the action of air and acids. If, on the contrary, too great a quantity of alkali has been used, the glass soon becomes dulled by exposure to the atmosphere, and is likewise much more susceptible of the action of concentrated acids. During the fusion, metallic oxides are absorbed by the glass, to which they impart various colours. The green hue so frequently seen is produced by oxide of iron being combined with the silica. When this glass is subsequently de-oxidised by the act of the solar rays, it loses the transparency, and becomes tinted with the various hues of the rainbow.

When the alkali predominates, and the mixture is composed of four parts of alkali and one of silica, the product is a vitreous transparent mass, which quickly absorbs moisture from the air, and resolves into a thick liquid. This substance is perfectly soluble in water, and is known by the name of *silicious liquor*, or solution of flints.

We thus obtain a solution of silica, but only through the medium of its combination with an alkali. If the alkali be neutralized by an acid, the silica will be precipitated from the solution, and fall to the bottom of the vessel. It is only when the silicious solution contains too great a proportion of water, or when an excess of acid has been added to it, that the precipitation does not take place until the liquid has been evaporated. This phenomenon has received several very different explanations; the probable cause is the excessive weakening of the attraction of cohesion between the particles of the silica. A more systematic and certain method of obtaining pure silica is, therefore, to evaporate the silicious solution diluted and saturated with an excess of acid, then again to dilute the residue with water, and wash the precipitate several times.

Among the bodies in whose composition silica forms the principal ingredient, and which exhibit its characters in the highest degree, we shall notice the following, as those of which it may be useful to the agriculturist to possess some knowledge.

1. All precious stones, with the exception of the diamond: viz., the *ruby*, *sapphire*, *emerald*, *chrysolite*, *topaz*, *hyacinth*, *amethyst*, *chalcedony*, *cornelian*, *agate*, and *garnet*.

2. *Fire-flints* and *petro-silex*. The first of these are found in heaps on all plains, especially in countries which have a sandy soil, and also in chalk hills, embedded in the purest chalk. Geologists have long been endeavouring to discover how the flints came to be lodged or produced in such a situation. There is some plausibility in the supposition that the lime has been converted into silica, for the transition of lime into a state of flint is often observed; and organic remains are frequently found in the middle of the flint, thus proving its recent formation.

The utility of this kind of flint is as notorious as it is extensive. The fabrication into gun-flints is of great importance. Formerly, this art was only known and practised in England, Spain, and France; it is now understood and used in the Austrian states. We may also observe that the ideas formerly entertained with relation to this kind of manufacture were rather singular; it was thought that the stones were found in a rough state upon the mountains, and cut and sharpened by machinery. At present, there is no doubt that they are manufactured by steel tools worked by the hands of skilful workmen. All fire-flints, however, are not equally well adapted for this purpose: some are too soft; while others, when struck by the hammer, fall into irregular fragments. Frederic William the First, king of Prussia, sent an armourer to St. Ange, to work there, and learn the art of making gun-flints. This man learned the art, and returning after a time, made flints with the stone found in Prussia; but they were so brittle that they flew to pieces on the second firing.

Besides this use of them, fire-flints are also employed in the manufacture of enamel, and of stone-wares; likewise for polishing glass, making burnishers for bookbinders and gilders, and in the composition of glass, especially of that beautiful substance called English flint-glass.

*Petro-silex*, or the *horn-stone* of the Germans, bears some resemblance to the preceding, but it has the dull appearance of horn and a scaly fracture.

3. *Felspar* has a lamellated texture, and is frequently flesh-coloured; it breaks into rhomboidal fragments. It is found, in beds and veins, in several other kinds of stones.*

4. *Quartz* is composed of crystalline and vitreous particles. It breaks into angular fragments. It is often found of a white hue and transparent, sometimes in large masses and sometimes in crystals. When these latter are large, transparent, and of a columnar shape, it is called *rock-crystal*.

5. *Granite*, *gneiss*, and *porphyry* are composite minerals, possessed of great hardness, and are formed of different stones. They constitute the basis of primitive rocks, and are also met with in large masses in plains. Granite is composed of quartz, felspar, and another stone of an argillaceous nature, called "*mica*."† The grain as well as colour varies in different ways. Gneiss closely resembles granite; it is composed of felspar, quartz, and mica; the parts are more intimately united than those of granite; and it generally presents a schistose and lamellated texture.

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* Common felspar is composed of—

| | Parts. |
|---|---|
| Silica | 62.82 |
| Alumina | 17·02 |
| Lime | 3·00 |
| Oxide of iron | 1·00 |
| Potash | 13·00 |
| Loss | 3·50 |
| | = 100 |

† Common mica is composed of—

| | Parts. |
|---|---|
| Silica | 47·00 |
| Alumina | 20·00 |
| Oxide of iron | 15·55 |
| Oxide of manganese | 1·70 |
| Potash | 14·55 |
| Loss | 1·20 |
| | = 10 |

Porphyry consists of felspar, quartz, and hardened clay or jasper, and sometimes also of a portion of mica.

6. *Sand* is probably formed for the most part of quartz, as it does not differ essentially from that mineral in its chemical composition. Immense floods of water, the action of the atmosphere, and probably also that of fire and other agents, have reduced the quartz to fragments, which have subsequently acquired a rounded form by rubbing against each other, in consequence of the motion communicated to them by the air and water.

Sand is divided into three principal varieties distinguished from each other by the size and transparency of the grains.

(*a*). *River sand* is composed of fine, clear, colourless grains; it is generally deposited by springs and rivers.

(*b*). *Pearl sand* is composed of large, round, semi-transparent grains. It is very frequently found below the surface of the ground. It is likewise washed up and deposited by running water.

(*c*). *Moving sand.* The grains of this kind are of various sizes. It is mixed with various heterogeneous matters, and generally carries alumina, and sometimes also lime, along with it. It is easily moved by the wind, and hence derives its name. It is frequently heaped up in valleys by currents of air and water, or collected in large quantities at the base of some obstacle. These heaps, if not united at the surface by the roots of plants growing on them, or by a certain portion of vegetable mould, are often carried away by the wind, and cause great damage to fertile meadows and plains on to which they are drifted.

Below the surface of the ground, sand is found in veins or elongated strata, between other layers of earth. It is to these beds of sand that we are indebted for our purest springs. Water, as it filters through them, deposits the heterogeneous matters which it contains, and increases in clearness during the whole of its course.

Although the grains of sand are for the most part composed of silica, they always contain small portions of alumina and oxide of iron. Sand has as little attraction for water as pure silica; and thence, as well as from the circumstance of its not having the attraction of cohesion for humus, arises the sterility that attends soil composed in too large proportions of that earth. When the sand is united into hard masses by adhesive matter, such as clay or lime, or by mechanical compression, it is called *sand-stone.* There are various kinds of this substance, all differing from one another in fineness and in density. They are taken out of the ground in a soft state, and cut for building purposes, to make door jambs, and window-sills; also mill-stones and wheels for grinding polishing tools are made from them. To this class also belong filtering stones, which allow water to pass through them like a sponge, and are, therefore, used to purify muddy water. This sand-stone was formerly scarce; but abundant quantities of it are now found in Saxony and in other countries.

## ALUMINA.

This simple earth is mostly contained in the compound mass, called *potter's earth* or *clay.* Hence the ancient name of argillaceous earth is derived; but as it is one of the most essential constituents of a salt known by the name of *alum,* modern chemists have thought proper to give it the appellation by which it is at present distinguished. It is composed of a metallic basis, called aluminum, united with oxygen. It must not be confounded with clay, which is a very compound body: clay of which we shall presently have to speak, is a mixture in various proportions of alumina with silica and oxide of iron.

Alumina is the earth which, next to silica, is found most frequently, and in the greatest abundance, in our soils. Clay, into the composition of which alumina always enters, exists in a greater or less degree in every soil, and is also found in extensive strata beneath the surface of the earth. Moreover, alumina forms a constituent part of most stones, and in some it is the principal ingredient. Organic substances contain a very small portion of it; and a trifling quantity is found in the ashes of most vegetable substances.

This earth is of great importance to the agriculturist. As a constituent part of clay, it always enters into the composition of vegetable mould. A perfect acquaintance with it is also essential to the agriculturist, in order to enable him duly to appreciate the influence of clay upon his fields, and the improvement or deterioration of the soil which it occasions. Clay likewise deserves attention on account of its utility in the manufacture of tiles and pottery. All these considerations should induce the agriculturist attentively to study, first, the properties of pure alumina; and, secondly, those of clay.

Although the utility of clay and its employment in the fabrication of tiles, bricks, and earthenware, have caused it to be known from the very earliest periods, it was not until very recently regarded as an elementary substance. It was for a long time confounded with earth in general, and afterwards assimilated sometimes with lime, and at others with silica, and supposed to have acquired an unusual character by the action of acids and other substances. It was not until the middle of the last century that alumina was proved to be a peculiar earth, which ought not to be confounded with others; and it was only at the commencement of the present century that its metallic basis was discovered. Notwithstanding the abundance of alumina, it is never found in nature in a state of absolute purity; it is usually combined with other earths and metallic oxides, and sometimes also with acids. In the garden attached to the college at Halle, white earthy substances were found, which were for a time regarded as pure alumina; but, on the one hand, it was proved, by a more precise chemical analysis, that, although consisting chiefly of alumina, it also contained lime and oxide of iron; and, on the other, it is probable that the substance in question was not a product of nature, but of the labours of certain alchemists who had resided upon the spot.

It is by chemical processes alone that alumina can be obtained perfectly pure, and separate from all foreign bodies. The easiest and most common method of obtaining it in this state, is to prepare it from alum, in which it exists in combination with sulphuric acid. The alum having been dissolved in water, the sulphuric acid is neutralized with an alkali, and the alum precipitated. Certain other processes are, however, necessary to purify it completely from the heterogeneous substances with which it is mixed.

Alumina is incapable of combining with carbonic acid, or at all events of forming a solid compound with it, as is the case with lime and magnesia; and this property particularly distinguishes it from magnesia. Several authors have, undoubtedly, spoken of the combination of alumina with carbonic acid; but De Saussure has shown that, chemically, pure alumina has not the slightest affinity for carbonic acid.

The physical properties of this earth are varied to a certain extent by the means which are taken to separate it from the substances with which it is united, and by the quantity and quality of the agents employed. Properties appertaining to clay have frequently been ascribed to alumina, and hence, undoubtedly, have arisen the variations in the accounts which different chemists have given of it. These discrepancies are not, however, of sufficient magnitude to cause alumina to be confounded with other earths.

It is a white pulverulent substance, and soft to the touch: it has, properly speaking, no taste; but, when placed on the tongue, causes a peculiar sensation arising from the absorption of moisture. The peculiar odour given out by crude clay, especially when moistened by breathing upon it or in any other manner, is not characteristic of pure alumina; and those who have considered it to be so are in error.

Alumina appears to have a greater affinity for water than any of the other elementary earths, since it retains a greater quantity of it; it likewise contracts a much stronger mechanical cohesion with this fluid than the others. But this latter property is found to differ considerably in the various preparations that are made with alumina. When it has been recently precipitated, it often contains, before it is dried, a quantity of water equal to six times its own weight; whereas, after having been dried at a moderate heat, it is incapable of retaining more than one and a-half times, or, at most, twice its own weight without dropping. When it has been made red hot, or even dried at a very high temperature, it becomes incapable of retaining more than a very small portion of water.

Alumina, when moistened with water, forms a paste possessing more or less of an unctuous character; but this paste, when made with pure alumina, is never so ductile as that which is formed of crude clay, neither does it receive any shape which may appear desirable to give it with the same facility.

This earth is insoluble in pure water. When it is mixed with a large quantity of that fluid, the particles being separated to a considerable distance from one another, appear to be semi-transparent; it becomes divided into extremely small molecules, which fall very slowly to the bottom of the vessel, the water not retaining the smallest quantity in solution. But if we impregnate that fluid with carbonic acid, it is, according to De Saussure, then capable of dissolving a small quantity of the alumina; this combination is, however, so feeble, that it soon decomposes when exposed to the air, the liquid which was at first limpid becoming turbid, and depositing the alumina at the bottom of the vessel in the form of a light gelatinous sediment.

At a gentle heat of about 18 or 20 degrees of Reaumur,[*] alumina allows the water which is imperfectly united with it to evaporate; but this degree of temperature is not sufficient to deprive it of all the fluid it contains, which, according to Buchholtz, amounts to 28 per cent. of the weight of the earth, and, according to

[*] **From 22 deg. 50 m. to 25 deg. of the centigrade.—FRENCH TRANS. From 72½ deg. to 77 deg. of Fahrenheit.**

De Saussure, to a considerably greater quantity. A very intense heat is required to effect an entire separation of the water from it.

Alumina is infusible at all ordinary temperatures; but in the focus of a large burning mirror, or in a fire fed by a stream of pure oxygen gas, it undergoes a species of fusion which does not, however, produce a complete vitrification. When mixed with lime, it may be completely fused; and when united to silica, its tendency to fusion is increased. Incandescence, however, always causes a very considerable alteration in its properties: the effect produced is not exactly that of fusion, but a kind of coagulation; the alumina loses the cohesive attraction for water, and becomes hard to the touch; when mixed with that fluid it no longer forms an unctuous paste, and, upon the whole, approximates more nearly in its properties to silica. Hence it happens that clay partly loses the ductility by the action of the fire. This, also, in some measure, explains to us the good effects that are produced by burning argillaceous soils. Alumina which has been made red hot, can only be restored to the primitive state by dissolving it in acids, and then precipitating by means of an alkali.

The earth in question does not appear to possess any alkaline properties, as it produces no change in the tint of the coloured papers which are used as tests for alkalies. It is also incapable of combining with sulphur like the alkalies, lime, and magnesia. We are not acquainted with any direct experiment which proves that alumina in a state of purity can enter into combination with oxygen, hydrogen, nitrogen, or carbon; it is, nevertheless, probable that it has an affinity for these substances; at all events, it has an affinity for their compounds, as is seen in the humus.

On the other hand, alumina has a very powerful affinity for the other earths, and in certain cases enters readily into chemical combination with them. It has a very great tendency to unite with silica, and, according to Guyton, can even precipitate that substance from its solution in an alkali. It is in consequence of this affinity that we so often find silica in nature combined with alumina in forming the compound called clay.

Lime, also, has a strong affinity for alumina. This explains the great fusibility of these earths when mixed; and still more clearly proves the power of alumina to decompose lime water, and separate the lime from its solution. If recently precipitated alumina be thrown into lime water, the liquid loses the alkaline taste, and the alumina falls to the bottom of the vessel, carrying the lime along with it. This separation of the latter can only result from the chemical affinity of the alumina for it, and from an actual combination of the two earths.

Alumina is easily dissolved in acids when it has been only partially dried; but after having been ignited, the dissolution is attended with greater difficulty. The solution takes place without effervescence or any rise of temperature. But this earth does not possess the power of depriving acids of all their acidity and of wholly neutralizing them; and in this respect it differs essentially from the alkalies and alkaline earths. The solutions have an astringent taste, and communicate a reddish tint to blue litmus paper. The results of compounds of alumina with acids are salts, some of which are crystallizable and others are not; but most of them are easily soluble in water. Alumina has a strong affinity for sulphuric acid, in combination with which it forms a viscous substance, which soon becomes moist when exposed to the air; if a little potassa is added to this compound, alum is formed. This earth may, however, contain a small portion of sulphuric acid without forming a saline compound; it is on this account that it is often difficult to effect a complete separation between these two bodies. When precipitated from a solution of alum, the alumina carries with it a small quantity of sulphuric acid, from which it can only be purified by repeated washings.

The muriatic, nitric, and phosphoric acids do not form crystallizable salts when brought into combination with alumina; most of them, on the contrary, produce viscous solutions.

The alkalies exert an action on alumina which it is very important to notice, both because it may serve as a distinguishing characteristic of this earth, and because it is frequently resorted to for the purpose of separating alumina from other substances. Lime and magnesia are not operated upon by pure alkalies, whereas alumina is completely dissolved by them. The combination takes place the more easily, in proportion as the alumina has been more recently precipitated, and contains a greater quantity of moisture; and it is very difficult to effect it when the earth has been previously ignited.

Ammonia will disclose a very small quantity of alumina, but potassa and soda dissolve a much greater proportion of it and with much greater rapidity. When moistened alumina is thrown into a warm, caustic, alkaline lie, it dissolves, and the liquid becomes transparent; but when the alkalies are completely saturated with carbonic acid, they no longer dissolve this earth.

All the alkalies, together with lime and magnesia, have a stronger affinity for acids than alumina possesses; they may, therefore, be used to separate the latter from its combinations. Thus, for example, the solution of alumina in an alkali is immediately decomposed by the addition of an acid; and the alumina itself is precipitated from its solution in an acid by the addition of any of the alkalies, the affinity of which for acids is greater than that of alumina.

## CLAY.

Clay, as we have already observed, is a compound of silica and alumina. These two earths are not merely mingled together in it, as is generally supposed, but chemically combined. A large proportion of the clay found in nature is also mixed with an extra quantity of silica, which exists in it in the form of sand of various degrees of fineness. This sand may, however, be separated from it by simple washing, or by a mode which experiment has lately shown to be much better, by boiling the mixture in water; but that portion of silica which is in direct combination with the alumina can only be separated by the action of chemical re-agents. Clay not only differs in appearance both from silica and alumina, but even its properties do not correspond in that degree which might be expected from the proportion in which these two substances are united in it. It has peculiar properties which a mechanical mixture of silica and alumina cannot be made to exhibit. Nature seems, indeed, to have reserved to herself the power of effecting this intimate union; for, although means have been discovered of effecting the combination of silica and alumina by chemical processes, the compound thus formed does not constitute a true clay.

Clay always contains iron in a higher or a lower state of oxidation; and it is probable that this metal constitutes an essential part of it. Oxide of iron is formed by the union of the metal with oxygen, and this combination is easily effected by the action of moisture. The colours of the oxide vary, according to the degree of oxidation, from black to yellow, brown, and red; the black tint indicates the lowest degree of oxidation, and the red the highest. Oxide of iron is an insipid inodorous powder, insoluble in water, but easily soluble in acids, and in combination with these latter it forms salts, which have the smell of ink. These ferruginous salts are, in their turn, decomposed by alkalies, because the latter have a superior affinity for acids. Astringent vegetables, or those which contain tannin, such as gall-nuts and oak-bark, separate the iron from the acid; and the precipitated iron being divided into very minute particles, tinges the fluid with a black hue.

Iron is sometimes operated upon in the ground by an acid, generally by carbonic acid, with which it forms an insoluble compound, wholly devoid of taste, and indifferent if not useful to vegetation. Other acids expel the carbonic acid from this compound, causing an effervescence like that produced when an acid is poured upon chalk. This circumstance once led me into error in a superficial examination which I was making on a sample of clay that was supposed to contain marl.

Oxide of iron is sometimes combined with phosphoric acid, especially in marshes, where that acid is produced by the decomposition of organic bodies. This compound is equally insoluble with the last, but it is nevertheless thought to be injurious to vegetation.

When iron is combined in the soil with sulphuric acid, produced by the decomposition of iron-pyrites, it forms the neutral salt commonly called "green-vitriol."

This salt, when mixed in a very small proportion of clay, appears always to exert an injurious action upon vegetation; indeed, sulphuric acid has never been found to be favourable to vegetation excepting upon calcareous soils, in which the acid immediately combines with lime, and thus forming gypsum, instead of being united with iron.

It is only when combined with vegetable mould, or other substances containing large quantities of carbon, and even then used in very small quantities, that the sulphate of iron (green vitriol) has produced a fertilising effect, or any great improvement of the soil. We shall enlarge further on this subject when we come to treat more particularly of manures.

Clay has probably been formed by the decomposition of hard rocks or stones. Many compact minerals, composed of alumina, silica, and oxide of iron, are decomposed by the action of the atmosphere, and transformed into clay; among the principal of these are argillaceous schists, which are frequently met with, and in some places compose whole mountain chains, and also felspar. This kind of decomposition is constantly going on before our eyes, naked rocks of clay-slate becoming covered with a stratum of clay, in which vegetables speedily take root. This light covering may easily be thickened and increased by separating the layers of the schist by means of a plough, and decomposing them with fresh manure, which seems to have the power of accelerating the disintegration.

The clay formed by this insensible operation of nature was, probably, in former ages, displaced by the action of running water, and deposited in the plains as we see it at present. Besides, it has, according to all appearance, attracted certain substances from the atmosphere, particularly oxygen.

The three substances of which clay is chiefly composed, viz., alumina, silica, and oxide of iron, are united in it in very different proportions, and we seldom find two kinds of clay of exactly the same composition. In the greater number of cases, silica is the predominating ingredient; the quantity of this substance frequently amounts to 93 parts in 100 without the mixture losing the properties of clay. Alumina very rarely forms the principal component part.

From the results of recent experiments made in our laboratory, we have found that clay which has been freed from sand by washing the silica, is still found to exist in two different states. First, when this clay is boiled for a considerable time and in a sufficient quantity of water, it deposits a kind of silica which certainly cannot be called sand, but which is nevertheless composed of grains even less minute than those which are precipitated from a solution of flints. The quantity of this silica which can be thrown off by ebullition, varies in different kinds of clay, and cannot be separated from them without great difficulty; and even when the separation has been effected with all possible care, there still remains a large quantity of silica in the clay, which can only be got rid of by chemical re-agents. We are still carefully prosecuting these researches, principally with the view of arriving at some positive conclusion with respect to a fact which at present we consider probable; viz., that all kinds of clay, when freed from that portion of silica which is united with them by a less intimate and merely in a mechanical combination, contain equal, or nearly equivalent, portions of that earth and alumina.

The quantity of oxide of iron contained in clay varies from one to ten or twelve parts in a hundred.

Sometimes clay contains oxide of manganese also; but this substance is rarely met with, and only in small quantities.

Clay is not always of one colour: it is found to be white, grey, brown, red, black, and in all the various shades of these colours. Sometimes the variations are chiefly attributable to combustible matters, such as humus, and to a kind of bituminous substance; these latter communicate to the clay a grey tint inclining to black, and sometimes make it quite black. But such clays when submitted to the action of fire become perfectly white; because, during this action, the carbon combines with oxygen, and escapes in the form of carbonic acid. The colours, however, mostly arise from the presence of oxide of iron, and sometimes also from that of oxide of manganese; the different shades depending partly upon the relative quantities of these substances contained in the clay, and partly upon the degrees of oxidation. The colour approaches the more nearly to bright yellow, deep yellow, or red, as the iron may be in a higher state of oxidation. Clays of this description do not become white when ignited; on the contrary, the oxide of iron which they contain takes up an additional quantity of oxygen, the iron becoming peroxidized, and the colour then changes to brick-red. All clays which contain from four to six parts in a hundred of oxide of iron, acquire this tint by ignition, the depth of the colour increasing in proportion to the quantity of oxide that is present.

Sometimes the clay derives the colour from the joint presence of oxide of iron, vegetable mould, and of bituminous substances. Clays of this kind acquire a lighter colour by ignition, because the vegetable matter from which their colour partly arises is volatilized; but they never become perfectly white, because the oxide of iron which is also concerned in the production of the colour remains behind. The loss of colour which these clays experience from ignition depends, therefore, upon the relative quantities of oxide of iron and of combustible matter which they contain: where the colour is very materially diminished in intensity, we may conclude that it was chiefly produced by the presence of combustible matters; if the contrary, that it arose principally from oxide of iron. Clays are sometimes found which are perfectly white, and these do not contain any inflammable substances. They are not, however, wholly free from oxide of iron, but the substance is present in the lowest degree of oxidation, and incapable of communicating any tint whatever to the clay. If, however, clays of this description are exposed to a white heat, the iron becomes more highly oxidised, and the clay acquires a yellow and sometimes a bright red tint. Should any white clays not change the colour when exposed to the action of fire, we may venture to conclude that they contain a very small quantity of iron.

Clay possesses the property of exciting a peculiar sensation in the organs of taste and smell in as high a degree, at least, as alumina, and it may thus be easily distinguished from other earths. When powdered and introduced into the nose, or applied to the tongue, it absorbs the moisture from the organ to which it is applied, and adheres firmly to it. Clay has, moreover, a peculiar odour not possessed by alumina, and which is called *earthy*. This is exhaled very copiously when clay which has been dry for some time is moistened, and hence the odour which generally pervades the atmosphere when rain falls after a drought. De Saussure attributes this effect to oxide of iron, but it is given out as strongly by clays which contain a small portion of that oxide as by those which contain it in much greater abundance. It is at present a doubtful point, whether this odour is exhaled by the clay, or is the consequence of some peculiar change in the atmosphere which surrounds it.

Among the properties of clay, none are so remarkable as their relations to water. When in a state of comparative dryness, although not absolutely free from moisture, it absorbs water with facility; and when it contains a considerable quantity of that fluid, it forms a more or less tenacious, adhesive, and ductile mass, which easily takes and retains any impression that may be given it, and is therefore capable of being moulded into all sorts of shapes. The property in question which renders this kind of earth so useful, is not possessed in the same degree by all clays; those which possess it in the greatest perfection are called fat or soft clays, and those which have it in a less degree poor clays. The plastic nature of this substance ought not to be attributed solely to the presence of alumina, for that earth in its pure state does not possess these qualities in so high a degree; they seem rather to result from the combination of alumina with silica, and even the oxide of iron seems to be partly concerned in their production. It is true that the fattest and most ductile clay contains the largest portion of alumina, and the brittle or poor clay the least quantity; but the degree of ductility is, nevertheless, not in exact proportion with the quantity of this earth which is present.

Clay, when saturated with water, is no longer pervious to that fluid. When water is poured upon a cake or basin made with clay paste, it remains on the surface without filtering through it. This faculty imparts great importance to the presence of clay in the upper stratum of the soil, and even to those which are underneath. It is the clay thus situated which prevents water from penetrating to a greater depth; were it not for this stoppage we should not meet with any springs without boring down to the solid rock. These beds of clay alternating with strata of earth permeable to water, are the most ordinary source of springs, because the water retained by them can only force a passage for itself in a direction parallel with them. These beds are also the cause of those swamps or collections of stagnant water which are sometimes met with in fields and plains, the water not being able to penetrate into the earth remains on the top of the clay strata until it is thoroughly evaporated, and thus shows itself on the surface of the ground.

When clay is macerated in a large quantity of water, it renders that fluid turbid and remains suspended in it, but the water does not dissolve the smallest portion. A considerable time elapses before this fluid again becomes completely limpid. It is in consequence of this property that the water of rivers, whose beds are composed of clay, is always more or less turbid; the detached and finely divided particles of the clay not being able to settle at the bottom by reason of the constant motion of the stream. It is also from the same cause that lands inundated by rivers which have burst their banks, are generally covered with clay; for the sand which the waters carry with them being heavier, quickly sinks to the bottom, and is deposited at random in heaps; while the clay being very minutely divided, and, as it were, diffused through the mass of water, is carried to a greater distance, and not deposited until the water has become stagnant.*

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* All the earths found in cultivated soils have a very considerable attraction for atmospheric moisture; and when they are mixed with organic decomposing substances, or pulverized, this power is materially increased. This property of the soils he cultivates cannot be too carefully kept in view by the farmer. It is one of the chief reasons why fallowing, deep ploughing, or subsoiling are so fertilizing in their effects; and why plants, growing on cultivated soils, are able to maintain themselves in health, even in the dryest seasons. The extent of this attractive property of the earths and soils may be ascertained experimentally, by either exposing a given weight of the previously well-dried earth to a moist atmosphere for a stated period, and then weighing it again to discover the amount of the moisture absorbed; or else, by confining a given portion of the dried earth in a confined portion of air, and then, by the hygrometer, determining the degree of dryness which has been produced by the earth confined in it.

In the experiments of Professor Leslie, made with a very delicate hygrometer, when thoroughly dried garden mould, introduced into a confined portion of air, saturated with moisture, indicated a dryness of 95 degrees,

| | | |
|---|---|---|
| The same weight of alumina, under the same circumstances, indicated a dryness of | 84 | degrees. |
| Carbonate of magnesia | 75 | „ |
| Carbonate of lime | 70 | „ |
| Pipeclay | 85 | „ |
| Shelly sea sand | 70 | „ |
| Greenstone resolved into soil | 92 | „ |
| Silica | 40 | „ |

In my own experiments with various earths and soils, the specimen was previously dried in a temperature of 212°, and then exposed to air saturated with moisture, at 60°, for three hours; under these circumstances—

| | | | | | | |
|---|---|---|---|---|---|---|
| 1,000 | parts | of | clay | gained | 29 | parts. |
| 1,000 | „ | „ | coal ashes | „ | 14 | „ |
| 1,000 | „ | „ | lime | „ | 11 | „ |
| 1,000 | „ | „ | gypsum | „ | 9 | „ |
| 1,000 | „ | „ | chalk | „ | 4 | „ |

When clay is exposed to frost, cracks or fissures are formed in it; indeed, it is sometimes completely disintegrated. This separation of masses of clay and comminution of their parts, is caused by the expansion

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And when exposed for eighteen hours to air at the temperature of 62° ("Essay on Salt," p. 7)—

| | |
|---|---|
| 1,000 parts of rich soil, near Maldon, in Essex, worth two guineas an acre, gained ........................................ | 25 parts. |
| 1,000 parts of the same field, which had been salted with 12 bushels of salt per acre, gained ........................................ | 27 „ |
| 1,000, which had been salted with 6 bushels per acre, gained ..... | 26 „ |

In the experiments of Professor Schnbler, the amount of the moisture absorbed by the earths was ascertained at four different periods, viz., 12, 24, 48, and 72 hours; the temperature of the atmosphere in which they were exposed was between 59 and 65° ("Journ. Eng. Ag. Soc.," vol. i, p. 196), and each earth was spread over a surface of fifty square inches. The amount absorbed is stated in grains:—

| 1000 grains of | 12 hours. | 24 hours. | 48 hours. | 72 hours. |
|---|---|---|---|---|
| Silicious sand ........... | 0 | 0 | 0 | 0 |
| Calcareous sand......... | 2 | 3 | 3 | 3 |
| Gypsum powder......... | 1 | 1 | 1 | 1 |
| Sandy clay ............. | 21 | 26 | 28 | 28 |
| Loamy clay............. | 25 | 30 | 34 | 35 |
| Stiff clay............... | 30 | 36 | 40 | 41 |
| Grey pure clay .......... | 37 | 42 | 48 | 49 |
| Fine lime ............... | 26 | 31 | 35 | 35 |
| Fine magnesia........... | 69 | 76 | 80 | 82 |
| Garden mould........... | 35 | 45 | 50 | 52 |
| Arable soil.............. | 16 | 22 | 23 | 23 |
| Slaty marl.............. | 24 | 29 | 32 | 33 |

Davy saw this property of all soils in its true light. "The soils," he said, "that are the most efficient in supplying the plant with water by atmospheric absorption are those in which there is a due mixture of sand, finely divided clay, and carbonate of lime (chalk), with some animal or vegetable matter; and which are so loose and light, as to be freely permeable to the atmosphere. With respect to this quality, carbonate of lime and animal and vegetable matter are of great use in soils; they give absorbent power to the soil, without giving it tenacity. Sand, on the contrary, which also destroys tenacity, gives little absorbent power. I have compared the absorbent power of many soils with respect to atmospheric moisture, and I have always found it greatest in the most fertile soils; so that it affords one method of judging of the productiveness of land."

1,000 parts of a celebrated soil, from Ormiston in East Lothian, when dried at a temperature of 212°, gained in an hour, by exposure to air saturated with moisture at temperature 62 deg., 18 parts. 1,000 parts of a very fertile soil from the banks of the river Parrett, in Somersetshire, under the same circumstances, gained 16 parts. 1,000 parts of a soil from Mersea, in Essex, worth 45s. an acre, gained 23 parts. 1,000 parts of a fine sand from Essex, worth 28s. an acre, gained 11 parts. 1,000 parts of a course sand, worth 15s. an acre, gained 8 parts. 1,000 parts of the soil of Bagshot Heath gained only three parts.—("Elements of Agri. Chem." 183.)

It is evident, therefore, that the power of absorbing moisture is, in a great degree, the measure of the fertility of all soils.

The quantity of water required to thoroughly saturate the various earths, is also a question of considerable importance to the farmer. This has been rewhich water undergoes in freezing, in which the crystals or needles of ice separate the particles of clay one from the other. On this account clay, which is to be used for the purpose of improving and ameliorating land, is

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cently determined experimentally by M. Schubler, whose work on this subject has been translated by James Hudson, Esq., the excellent Secretary to the English Agricultural Society. The following table shows the result of the German Professor's researches ("Jour. Eng. Agri.," vol. i. p. 184):—

| | Real quantity of water in a cubic foot, when saturated. | When dry. | Weight of a cubic foot when saturated with water. |
|---|---|---|---|
| Calcareous sand* | 31·8 lbs. | 113·6 lbs. | 141·3 lbs. |
| Silicious sand | 27·3 | 111·3 | 136·1 |
| Gypsum powder | 27·4 | 91·9 | 127·6 |
| Sandy clay | 38·8 | 97·8 | 129·7 |
| Loamy clay | 41·4 | 88·5 | 124·1 |
| Stiff clay, or brick earth | 45·4 | 80·3 | 119·6 |
| Pure grey clay | 48·3 | 75·2 | 115·8 |
| Pipe clay | 47·4 | 47·9 | 102·1 |
| The carbonate of lime | 47·5 | 53·7 | 103·5 |
| Fine carbonate of magnesia | 62·6 | 15·8 | 76·3 |
| Garden mould | 48·4 | 68·7 | 102·7 |
| Arable soil | 40·8 | 84·5 | 119·1 |
| Fine slaty marl | 35·6 | 112·0 | 140·3 |

Another important property of soils to be considered by the farmer, when he is endeavouring to improve the composition of his land by an admixture of earths, is the property which these possess of retaining their moisture when exposed to the action of the atmosphere. This property has also been examined by Professor Schubler, and his experiments are very valuable to the cultivator, as comparative results; otherwise, experiments of this kind carried on in a close room always differ very materially in the amount of evaporation from that of the same soil in situations exposed to the wind and sun. The mode adopted in these experiments was as follows (*Ibid.* p. 109):—"We place on a round surface of tin plate, having a raised border, a given quantity of the earth to be examined. Having previously saturated this fully with water, we spread it out evenly, and ascertain the weight of the whole: we suffer it to remain for several hours in a close room to evaporate, and again weigh it, to ascertain the quantity of water evaporated. If we make the experiment with many earths at once, we shall be able to institute a comparison among them with the greatest certainty in reference to this point. To obtain accurately the quantity of water contained in the earth at the commencement of the experiment, we afterwards dry it in an artificial heat, and thus easily reduce the quantity of evaporated water to hundredth parts of that contained in the earth.

| | |
|---|---|
| Let the weight of a wet earth be | 310 grains. |
| The weight of the same earth after 24 hours | 260 |
| The weight of the perfectly dry earth | 200 |
| Therefore, the amount of water evaporated in 24 hours will be. | 50 |
| And the water in the earth at the beginning of the experiment. | 110 |

The following table contains the results of my experiments in reference to always first submitted to the action of frost, in order that by the perfect comminution and division of the particles, it may be better adapted for mixing and amalgamating with the soil on which it is laid.

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* The reason why the real quantity of moisture in a soil cannot be accurately determined by merely comparing the weight of a given measure when dry with the same measure when wet, is, that some soils when they are dried materially contract, and expand when wet, as every cultivator of a clay soil can attest.

Moistened clay, even when subjected to the action of heat, parts with the water with very great reluctance, and the more so in proportion to its fatness; and it retains that fluid more tenaciously than any other earth. After the evaporation of the water it becomes more or less hard, according as it is rich or poor. Moist clay, when exposed to a high degree of heat, often breaks and falls to pieces; the vapour, by its elastic power, opening a passage for itself, and breaking the substance in which it is enclosed. This is the reason that, in making tiles, it is necessary to dry them first by exposure to the air, and then to heat them gradually in the kiln.

Clay, in drying, always contracts and loses a portion of its bulk. This contraction arises from the evaporation of the water, in consequence of which the particles of clay approach each other more closely; and this quality produces the fissures which, during very hot and dry weather, are formed on the surface of argillaceous soils. The same circumstance also renders it necessary to model tiles and earthenware vessels one size larger than that which is required after baking.

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this point, with 200 grains of the several earths at a temperature of 65¾ deg., spread out over a surface of ten square inches; and in stating the results of all these experiments, the quantity of evaporation is given, as from every 100 parts of water contained in the earth.

| | | |
|---|---|---|
| Silicious sand ........... | evaporation in four hours, | 88·4 |
| Calcareous sand ......... | ” ” | 75·9 |
| Gypsum powder......... | ” ” | 71·7 |
| Sandy clay .............. | ” ” | 52·0 |
| Loamy clay ............ | ” ” | 45·7 |
| Stiff clay, or brick earth . | ” ” | 34·9 |
| Pure grey clay .......... | ” ” | 31·9 |
| Fine lime................ | ” ” | 28·0 |
| Magnesia................ | ” ” | 10·8 |
| Garden mould .......... | ” ” | 24·3 |
| Arable soil ............. | ” ” | 32·0 |
| Slaty marl.............. | ” ” | 68·0 |

This reluctance to part with the moisture with which the soil is combined increases, the cultivator is well aware, with the tenacity of his land; his experience in this respect agrees entirely with the experiments of Professor Schubler.—*Johnson on the Fertilizers*, p. 264.

Clay can only be completely deprived of moisture when heated to a bright red heat: it then contracts still further, and undergoes a kind of condensation which brings the particles still more closely together. The terms of "shrinking" and "contraction" are used to denote this approximation of the particles of clay occasioned by the action of heat, to which rich clays are more exposed than those of inferior quality.

But the contraction of any particular kind of clay is always the same when subjected to a definite degree of heat; or, in other words, when it is submitted to any one particular temperature, the clay will always experience a similar diminution of volume. This property has introduced clay in the construction of pyrometers for measuring very high temperatures.

Clay does not fuse with the heat of an ordinary coal fire; but when the fire is strongly increased by a bellows, or fed with oxygen gas, the fusion takes place. The addition of lime greatly augments the fusibility of clay, and the same effect is produced by oxide of iron. Hence, a large addition of lime or of oxide of iron in the fabrication of bricks and of earthenware is very injurious, because, as frequently happens, the bricks or vessels so formed melt and fall to pieces when the temperature of the furnace is very high. But in small quantities these substances may be of service, as they induce the commencement of vitrification, a greater condensation of the particles, and, consequently, an increase of solidity in the mass.

The properties of clay which has been heated to redness, differ greatly from those of the same substance in its natural state. The fragments of the former are often sufficiently hard to give out sparks when struck with steel, and cannot be softened by immersion in water. When pulverized and mixed with that fluid, they no longer form an adhesive, unctuous, and ductile paste, but the powder allows water to pass through it, retaining a very small quantity, and then it resembles sand or silica. No artificial process can restore that ductility to baked clay which it previously possessed; nevertheless the action of the atmosphere, of moisture, and of animal manures, seem to bring it back by degrees to the natural and original state.

Generally speaking, air appears to exercise a very powerful influence on clay, whether baked or unbaked. This action is peculiarly apparent in the beneficial effect produced upon land by clay which has been exposed to the air for a long time. It is generally known that the earth of old walls and ovens forms an excellent manure, and increases the fertility of the soil.

It was formerly thought that clay absorbed the nitre contained in the air. It has, indeed, been ascertained that it favours the formation of nitrate of potassa in saltpetre houses; but the atmosphere never contains nitre ready formed. Various observations and experiments however, tend to induce the belief that clay, when exposed to the air, absorbs nitrogen, hydrogen, and all the other animal exhalations contained in the atmosphere. When kneaded, clay is exposed for a considerable period in large masses, and in a damp situation it assumes all the characters of putrefaction. Ammonia is then formed in it, thus proving the presence of nitrogen, which is a constituent portion of ammonia.

Even if it has not yet been proved that pure alumina absorbs oxygen from the atmosphere, there is no doubt of that property being possessed by clay. Humboldt has satisfactorily ascertained its existence in all the kinds of clay which he has examined, and even in compact slate.

The absorption of various substances, both known and unknown, from the atmosphere, renders clay lighter, thinner, and less tenacious. This fact is established by several chemical experiments and analytical examinations. I have analyzed clay taken from the surface of the ground, as well as that taken from a considerable depth; both were found to contain the same proportions of alumina, silica, and oxide of iron, but the former was decidedly poorer than the latter. Since the action of the air renders clay less compact, we can easily understand the cause of the benefit which a very argillaceous soil derives in this respect from the operations of turning it up, ploughing, digging it with the spade, &c.; for the upper stratum of the soil is thus brought into contact with the atmosphere at a greater number of points, the air is enabled to penetrate more deeply into the ground, and convey a large quantity of those substances which it contains; and thus the soil is rendered lighter, and a more complete separation of its parts is effected.

Acids exert little action upon those clays which are free from lime. They do not produce any effervesence unless a large quantity of carbonate of iron is present. Alumina and oxide of iron certainly are, when in a free state, easily soluble by acids; but, when mixed in clay, they are protected from the influence of these substances by the silica with which they are surrounded or united. Acids, when poured upon clay, undoubtedly dissolve a portion of these component parts, but not the whole of them. The quantity dissolved is greater in proportion as these substances predominate over the silica. Thus, a rich clay will give a larger portion of alumina to an acid than a poor one. Acids will also absorb a larger quantity of oxide of iron from a clay which is rich in that metallic body than from one which contains little of it. This accounts for the fact that land which contains a considerable quantity of oxide of iron is, in consequence of that very circumstance, inferior in point of fertility to other land which, although similarly constituted in all other respects, contains a smaller portion of this oxide. This substance is not in itself injurious to vegetation, and only becomes so when combined with certain acids. Nevertheless, as acids are easily formed in the ground, and as they more readily operate upon clay which is rich in oxide of iron than on that which contains a small quantity, their deleterious effects must necessarily be more sensible in the former than in the latter kind of soils.

Most acids, then, do not possess the power of completely decomposing clay; that is, of effecting a thorough separation between the alumina and oxide of iron, and the silica. Clay may be boiled in nitric or muriatic acid without the alumina and oxide of iron being completely dissolved. Concentrated sulphuric acid is the only one which is capable of producing an entire solution, and it can only do so when employed in considerable quantities and boiled for a long time in contact with the clay. An easier method of separating the alumina and the oxide of iron, is to mix the clay with an alkali (caustic alkalies answer the purpose best) and expose the mixture to a red heat, when a quantity of acid sufficient not only to saturate the alkali, but also to leave an excess of it, must then be poured upon the fused mass. This excess of acid soon dissolves the alumina and oxide of iron, and the silica may then be completely separated. The alkali seems to diminish the attraction of cohesion between the silica and the oxide of iron, and to weaken the resistance which this oxide, when mixed with alumina, opposes to the action of acids. This process is the surest and the easiest way of decomposing clay.

Besides those bodies which belong essentially to clay, viz., silica, alumina, and oxide of iron, we frequently find other substances in a state either of mixture or of combination.

Clay generally contains sand in fine grains, which cannot be completely removed by ebullition; and it is also frequently mixed in greater or less quantities with a coarse kind of sand, which is easily separated from it by washing. This mixture is called argillaceous earth. We shall have occasion to mention it again presently. Humus, or vegetable mould, is often found in clay, and appears to be rather combined than simply mixed with it. All clays which lie on the surface of the land, or at a small depth below it, contain more or less of this substance. We have found a very considerable quantity of it in clay which was five toises below the surface. Clay is often accompanied by lime in countries where that substance is very plentiful; indeed, it is oftener found united with this earth than without it. Sometimes the lime is mixed with it in small pieces, and it is then easily distinguishable by sight; in other cases these substances are so combined together that the lime can only be detected by chemical analysis. Lime is also found in clay, in a state of union with sulphuric acid, in the form of gypsum or the sulphate of lime. When the quantity of lime contained in clay reaches a certain proportion, the combination is distinguished by the name of marl, a substance which we shall hereafter examine more particularly.

The physical properties of clay, the ductility and power of retaining water, may be greatly modified by these combinations, and in proportion to the quantities in which these substances are mixed with it. Clay, mingled with coarse silica, sand, vegetable mould, and lime, diffuses itself more easily through water, retains a less quantity of that fluid, dries more rapidly, and does not harden so much as pure clay. When moistened, it is also less unctuous and ductile.

The quantities in which these substances combine with clay are subject to infinite variation; hence also the properties of clay itself are infinitely variable. In addition to this fact, it must be observed that, as the essential and constituent parts of clay, viz., alumina, silica, and oxide of iron, influence the physical properties, there must, necessarily, be an endless variety of clays, all of which—at least as far as composition goes—may be regarded as pure. It is, therefore, impossible to arrange these different kinds in any definite classification, because the several varieties are not marked by any distinguishing characteristics, there being, on the contrary, an endless variety of gradations from the richest kind of clay to the poorest. We shall, however, distinguish some of the most remarkable by particular names, and describe their most essential properties, because a knowledge of them may be interesting to agriculturists as well as useful in thereby enabling them to derive the greatest possible profit from the land at their disposal.

The *kaolin* or porcelain earth is the purest and finest of all the clays, and is the variety employed in the fabrication of fine porcelain. It is found in different countries: in Germany, near to Aue in the Hartz mountains; near to Giehren, Strablow, Teichenau, and Tarnorwits, in Silesia; near to Grunnerits in the circle of Saal; near to Vienna in Austria, Passau, Hochst, &c.

Kaolin has probably been formed by the decomposition of felspar. It is of a white, or greyish white, or yellowish white colour, sometimes even inclining to red: it falls to powder spontaneously when immersed in water; when pounded in a dry state it forms a powder which, although dry, is soft to the touch and adheres slightly to the tongue: it is sometimes found mingled with particles of lime and mica. The proportions of their constituent parts vary much. According to Wedgewood, the kaolin found in Cornwall contains sixty parts in a hundred of alumina, and twenty parts in a hundred of silica; other varieties contain smaller portions of these constituent parts. It does not contain either iron or the oxide in large quantities.

Good porcelain is also obtained by mixing together certain proportions of different kinds of clay.

*Pipe-clay* is employed chiefly in the manufacture of pipes for smoking. Next to kaolin, it has, of all kinds of clay, the purest colour; its shades and hues, however, vary considerably; it is found white, grey, inclining to blue, and even black; and often contains combustible matters, which give to it a deeper hue. When heated in the fire it becomes white; sometimes, however, preserving a reddish tint. It falls to pieces in water, and does not acquire any great degree of tenacity by uniting with that fluid. Various qualities of it are met with: that found near Cologne is reckoned among the best; that from the environs of Maestrecht the next in quality; but very good pipe clay is also found near Buntzlau and Plauen; likewise at Weissensprünck in the Electoral March, and in Hesse, Wurtemburg, &c.

*Bole* is one of the fattest of all the clays: it is manufactured into little tables, which, when stamped, are sold under the name of sealing earth *(seigel-erde.)* Its colour is tile red, brown, and occasionally pure white. The Armenian bole is generally considered to be one of the best and most valuable of all the varieties. This kind of clay is very soft to the touch: when mixed and united with water, it forms a very tenacious and unctuous paste. It dries and becomes exceedingly hard when exposed first to the air, and then to the action of the fire. White bole acquires, from ignition, a yellowish tint, or a colour slightly inclining to red.

*Blood-stone* or *red ochreous clay* is a kind of bole which is very rich in oxide of iron. It is found in various places; but that which comes from Striegau, Zittau, and Neuremberg, is the best in Germany.

*Potter's-clay* or *tile-clay* derives its name from the use which is made of it in the manufacture of tiles and common earthenware. In flat countries it is found in abundant and extensive strata. It is very tenacious and unctuous, but, nevertheless, often contains a small quantity of sand and lime. It is soft to the touch, and if placed on the tongue adheres firmly to it. It possesses in an eminent degree the power of absorbing water, but does not fall to powder on being immersed in that fluid, but becomes, on the contrary, very tenacious and ductile. It becomes very much hardened by drying, and has a great tendency to split. When ignited, it is rendered as hard as stone, and it can then no longer be pulverized by rubbing between the fingers; or, indeed, in any way without considerable difficulty.

*Fuller's-earth* is a poor clay, used for the purpose of removing dirt or grease from cloth, &c. It was formerly imagined that this substance was not to be found any where except in England; but it is now well known, that many kinds of clay found in Germany, are equally well adapted for the purposes just mentioned. The exportation of Hampshire fuller's-earth was formerly forbidden in England.

Fuller's-earth is friable; it soon falls to powder in water, without, however, becoming much divided, or forming a mixture like the plastic mass used in pottery.

English fuller's-earth is brown, and intersected with yellowish veins; after ignition it assumes a black tint, which it again loses if the incandescence be long continued.*

The kind of clay which, in the classification of the different soils, I distinguish by the name of *marshy earth*, may, as far as regards the quality and other properties, be assimilated to fuller's-earth. It contains only a small portion of alumina, but equally as much silica, and sometimes also a small portion of lime. The degree of tenacity and adhesiveness possessed by it is very trifling: it is tolerably hard; but, nevertheless, always forms dust; and it breaks without difficulty as soon as it is moistened: so that water courses made in it do not remain open for any long time, but are speedily filled with mud. When it is dry and formed into clods, they easily break and separate themselves after a light rain. I distinguish it from soft or plastic argillaceous earth, because the latter is a mixture of rich or poor clay with coarse-grained silica or chalk.

*Clay iron ore*, or *marshy ferruginous earth* is, for the most part, composed of clay, and a large proportion of carbonate and phosphate of iron, and which together form a hard mass. Not only the nature of it, but also the phosphate of iron which it contains, renders it very injurious to vegetation, both when it is disposed in strata immediately below the surface of the ground, and when it is partly dissolved and brought into contact with the roots of plants. It is decomposed by

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* The constituents of fuller's-earth, according to Klaproth, are as follows:—

| | Specimen from Reigate, Surrey. | Specimen from St. Nimptch in Silesia. |
|---|---|---|
| Silica ............ | 53·0 | 48·5 |
| Alumina........... | 10·0 | 15·5 |
| Lime ............ | 0·5 | — |
| Magnesia ........ | 1·25 | 1·5 |
| Oxide of iron .... | 9·75 | 7·0 |
| Common salt ...... | 0·1 | — |
| Water ............ | 24·0 | 25·5 |
| Loss ............ | 1·4 | 2·0 |
| | 100·0 | 100·0 |

long exposure to the atmosphere, and, therefore, can only be used for subterranean structures; at all events, this is the case with many varieties of it. It is very durable under water. The colour is either brown or an intermediate hue between deep brown and deep yellow, and it often contains veins of a bluish black tint.

It has sometimes been worked for the extraction of iron, and hence is usually included by mineralogists in the list of iron ores.

When this earth or mineral exists on the surface of the ground, it renders the soil unfit for vegetation of any kind, even pines cannot grow upon it. The only means of rendering such land available for cultivation, is to dig up the earth to a certain depth: this method has actually been applied on pieces of land of small extent, and often at a very great expense.

### LIME.

*Lime* is one of the most abundant substances in nature; it forms whole mountain chains, and together with other earths and metallic oxides constitutes a great number of minerals. It also exists in large quantities in the bodies of animals, forming the principal ingredient of bones and shells. It likewise forms a constituent part of all vegetables; at all events, it is invariably found in their ashes, and it exists in solution in almost all natural waters.

Lime, till lately, has been regarded as an elementary substance; modern experiments and observations have shewn that it is a compound. It is composed, in fact, of a peculiar metal called calcium and oxygen. The frequent occurrence of lime in the bodies of animals, the numerous impressions and petrefactions found in calcareous rocks, the evidence by which it is proved that this lime is derived from testaceous animals, and, lastly, the numerous reasons which induce us to believe that organic bodies produce lime—all these considerations, taken collectively, have led naturalists to suppose that lime is a product of organic nature. But this opinion is contradicted by the existence of the substance in question in primitive rocks, and at elevations where neither petrefactions nor impressions of organic bodies are found.

Lime belongs to the class of alkaline earths, and its properties seem to bear a close resemblance to those of the alkalies. It has a strong tendency to combine with acids; and, as it occurs everywhere, we always find it in combination with one or the other of those bodies, except indeed in the craters of volcanoes, in which we occasionally meet with lime in a pure state, being robbed of the carbonic acid by the action of heat. The acids with which it is most frequently combined are the carbonic and sulphuric; though we occasionally, but not so often, find it united with the phosphoric, muriatic, boracic, and nitric acids.

*Carbonate of lime*, also known by the name of *crude lime*, is the base of limestone and chalk, and also forms a constituent part of other minerals. It exists in marl in combination with clay, and in many soils it is found mixed more or less abundantly with clay and sand. It can be separated from every mixture, and, by means of certain artificial processes, may be exhibited in a state of purity.

Pure carbonate of lime is a light, white, insipid, and inodorous powder. According to the most accurate analysis, it is composed of 56 parts in a 100 of pure lime, 40 parts of carbonic acid, and 4 parts of water. This latter portion is essential to it, and forms part of the fundamental constitution, and is not evaporated by a moderate heat; carbonate of lime ceases to be such before it parts with the water. This fluid is not contained by it in a liquid form, but as a solid, and in a state of crystalization.

Carbonate of lime easily mixes with pure water, but does not dissolve in it; and if the fluid is left quiet, the carbonate soon subsides. When mixed with water so as to form a thin paste, and then placed upon a horsehair sieve, it retains a quantity of the fluid equal to half its own weight, but allows it to evaporate even more easily than it escapes from sand. But this substance may also be dissolved in water which is saturated with carbonic acid. In order to effect this solution, it is only necessary to stir the substance repeatedly in the water. The quantity of carbonate dissolved will depend upon the amount of carbonic acid that is contained in the water, and will increase or diminish in exact proportion with it. This compound is called *the solution of carbonate of lime in water impregnated with carbonic acid.* It is frequently met with in nature, and the waters of most springs, and especially of those which issue from calcareous mountains, are of this kind.

A solution of lime in an excess of carbonic acid, whether produced by natural or artificial means, is rapidly decomposed, and the carbonate of lime separates from the fluid as soon as the acid is removed. This effect is produced by mere contact with the atmosphere, especially when the water is agitated; and this is, doubtless, the reason that certain waters used for irrigation produce so very much greater an effect upon meadows when they flow over them immediately after issuing from their source, than when they are conducted to a considerable distance, and exposed all the while to the influence of the atmosphere. In the latter case the water which was previously limpid becomes turbid, and deposits the lime which it held in solution.*

When calcareous earth is dissolved in water, it adheres to the vessel which contains it, and forms a crust, or collects in masses, becomes agglomerated, and falls into various shapes. When a solution of lime in an excess of carbonic acid is boiled, the acid escapes yet more rapidly; and this may account for the fact, that spring water, when boiled, becomes turbid, and deposits a sediment, which forms a crust round the vessel. This crust is formed by the precipitated carbonate of lime, although many uneducated persons take it for nitre.

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* That the portion of saline matters contained in spring water is diminished by being used for the purposes of irrigation, has been proved by the experiments of Dr. H. R. Madden, who found that a gallon of water, "clear as crystal," issuing from the base of the Pentland Hills, contained before passing over a meadow ten grains of common salt, and four grains of carbonate of lime (chalk), but after passing over the meadow, a gallon of the same water contained only five grains of common salt and two of carbonate of lime.—*Trans. High. Soc.*, vol. viii. p. 687.

Bodies which absorb carbonic acid, also precipitate lime from the water which held it in solution. The caustic alkalies, potassa, soda, and ammonia, instantly produce this effect by uniting with the acid, which dissolve the lime, thus precipitating the latter. The alkalies, even in their ordinary state of carbonate, generally have the same effect, for they are not entirely saturated with carbonic acid.

Carbonate of lime undergoes no change when exposed to the action of moderate heat, except that it parts with some or all of the water which adheres to it, and becomes drier. But when exposed to a violent heat it loses the whole of the water, as well as the carbonic acid; becomes caustic, and acquires alkaline properties. In this state only, lime can be regarded as chemically pure; and it is then called calcined or quick lime. This substance has in all ages and in all countries been used for the purposes of building. We shall not here attempt to describe the preparation of lime on a large scale, but content ourselves with considering its physical and chemical properties, in order to be enabled to account for all the remarkable phenomena it produces, as well as the effects when it is employed as a manure or as mortar.

Quick or calcined lime has an alkaline, caustic, and very disagreeable taste; and, like the alkalies, it possesses the property of alternating vegetable colours. When fragments of lime in this state are moistened with water, they absorb a considerable quantity of that fluid and yet remain dry. A disengagement of heat is soon observed, which gradually increases; and finally the fragments split, burst asunder, and fall into a very white and light powder, which is soft and dry to the touch. The degree of heat produced by this combination of lime with water, sometimes exceeds that of boiling water; and when a considerable quantity of lime is slaked in a dark place, light is frequently emitted.

Even when lime is united with a quantity of water equal to the fourth part of its own weight, it does not then become moistened, but absorbs and solidifies the whole of the fluid, and its own weight is proportionably increased. This solidification of the water affords an explanation of the rise of temperature always attendant on the operation of slaking lime, and formerly all sorts of imaginery causes were assigned to account for this phenomenon. The water absorbed by the lime passes from a liquid to a solid state; and the caloric to which this liquid doubtless owes its fluidity, is set at liberty and escapes. The water which has entered into combination with lime passes into a solid state, and can only be separated from it when that substance is heated to ignition.

Lime that has been slaked may easily be mixed with water, and the union takes place without any further disengagement of heat. When diffused through a large quantity of water, lime forms a kind of fluid paste; and if the quantity of water be still further increased, a thin liquid will be formed, known by the name of *milk* or *cream of lime*. Lime when slaked is still caustic, although not to so great a degree as quicklime; it has an acrid, disagreeable taste, and alters the colour of paper stained with vegetable juices from blue to green.

Lime which has been calcined, but not slaked, likewise becomes changed by exposure to the air; its fragments fall to powder more or less quickly in proportion to the degree of humidity contained in the surrounding atmosphere; it absorbs the moisture of the air, and thus becomes slaked of itself, often exhibiting a perceptible increase of temperature. But it also becomes changed in another way, gradually losing its causticity and taste, and becoming unfit to be made into mortar. It also absorbs carbonic acid from the air, and thus gradually repasses to the state of a carbonate, so that it cannot be restored to its former condition unless it be calcined afresh.

The time requisite to effect the passage of quicklime into a carbonate by exposure to the air depends upon the humidity of the atmosphere, and the quantity of carbonic acid which it contains. The greater the quantity of moisture and of carbonic acid, the more rapidly does the transition take place. Calcined lime does not absorb any carbonic acid from dry air, even when that acid is present in large quantities: moisture is absolutely necessary to bring about a union of these two substances. Calcined lime may, therefore, be kept in a dry place for a considerable time without losing its properties. It is not, however, safe to trust to this method in cases where it is desirable to have the lime perfectly pure, as, for example, when it is to be used as a remedy for swellings on the bodies of animals; it ought, in such cases, to be kept in closely stopped glass vessels.

Calcined lime may be completely dissolved in pure water without the intervention of any other substance, and it does not lose this property even when it has been previously slaked. But a very large quantity of water is necessary in order to dissolve it completely, viz., 780 parts of water to one of lime. In order to effect this solution, it is only necessary to agitate either quick or slaked lime in water. The solution thus formed is called lime water; it is perfectly clear and transparent, and has the alkaline taste of lime. Its effect on vegetable colours is precisely the same as that produced by the solution of an alkali.

When lime-water is exposed to the atmosphere, a white crust forms over its surface, which ultimately becomes so heavy that it falls to the bottom of the vessel and is succeeded by another, until the whole of the lime is precipitated from the solution. The mixture thus formed at the bottom of the vessel is called cream of lime. The effect just mentioned is produced by the absorption of the carbonic acid contained in the air by the lime. This acid combines with the lime, which being thus converted into a carbonate, can no longer be held in solution by the water. Lime-water must, therefore, be kept in tightly stopped glass vessels.

Lime, which is completely dissolved in water, and even that which is only mechanically mixed or suspended in that fluid, as is the case in the milk of lime, quickly absorbs carbonic acid, and becomes saturated with it, when it is briskly agitated in that gas. All waters containing carbonic acid are robbed of it by the action of lime; hence it also decomposes a solution of lime in an excess of carbonic acid. Lime is, therefore, one of the best re-agents that can be employed for detecting the presence of carbonic acid in liquids or gases. It is by a process somewhat of this nature that the quantity of carbonic acid contained in the atmosphere or in water is determined.

Calcined lime easily combines with sulphur, producing various phenomena, according to the manner in which the combination is effected. When caustic or quicklime in a state of powder is mixed with powdered sulphur, and this combination is heated to redness, it becomes brown, and the two substances unite. The product, which is called *sulphuret of lime*, or liver of sulphur, has no smell, and is simply a compound of lime and sulphur. When it is exposed to the air, or moistened with water, the peculiarly fetid odour of sulphureted hydrogen is given off; part of the sulphur decomposes the water; the hydrogen of the latter dissolves a portion of the sulphur and produces an acid, which immediately unites with the lime, and thus the *hydro-sulphuret of lime* is formed.

The same compound is obtained by boiling sulphur in lime-water, or milk of lime; the liquid becomes brown and exhales the same odour. This compound of sulphur, when prepared in the dry way and afterwards moistened with water, undergoes decomposition by exposure to the air, the sulphur absorbing oxygen. When mixed with acids it is rapidly decomposed, and gives out an additional quantity of sulphureted hydrogen; very good artificial imitations of natural sulphureted baths may thus be made.

Lime and phosphorus may also be made to combine by being fused together. The resulting compound is a brown substance called *phosphuret of calcium*, which possesses even to a greater degree than the sulphuret the power of decomposing water. In this combination a great quantity of phosphureted hydrogen gas is disengaged, part of which escapes and takes fire upon coming in contact with the air, while the rest is retained by the lime, and cannot be disengaged except by the intervention of other acids.*

As far as present experience goes, it does not appear that lime combines with pure hydrogen, nitrogen, or carbon; but there is no doubt of its being able to unite with these substances when they are combined together, or of its capability of uniting with carbureted hydrogen and the compounds of carbon, nitrogen, and hydrogen. This fact shows us the reason that organized bodies are attacked and destroyed by quicklime. When such bodies are placed in contact with the lime, they lose their cohesion and colour, and are reduced to a friable mass. Carcasses covered with lime are rapidly decomposed without exhaling those noxious vapours which accompany their putrefaction under other circumstances. It is on this account that quicklime is placed in the coffin with the bodies of those individuals who have died of contagious diseases. Even living organized bodies, as tender plants and seeds, insects and their larvæ are also attacked and rapidly destroyed by quicklime.

These phenomena, which are produced by lime as well as by the alkalies, sufficiently prove that it has an affinity for the elements of which organized bodies are composed, viz., hydrogen, carbon, and nitrogen, as it is impossible to believe that a substance which acts with so much energy upon organic bodies, can be destitute of affinity for their elements; we are rather led to conclude that it tends to combine with some one or more of these elements, which are united in all organic bodies in certain definite proportions; and that by its combination it destroys the equilibrium of the whole mixture.†

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* The phosphuret of calcium decomposes the water, the hydrogen of which combines with the phosphorus forming phosphureted hydrogen; while its oxygen combines partly with the calcium forming lime, and partly with the phosphorus forming phosphoric and hypo-phosphoric acids. These acids unite with the lime and form phosphate and hypo-phosphate of lime.

† When lime is mixed with tallow, and certain other organic substances, it forms a soap. Lime, and some of its salts, when mixed with common alkaline

Slaked lime does not produce these effects to the same extent as quicklime, because its action is not assisted by that increase of temperature which accompanies the action of the latter; nevertheless, it has sufficient power to accelerate the decomposition of organic substances. On this decomposing power, the beneficial effect which it produces when used as a manure in a great measure depends. It accelerates the decomposition and disintegration of the manure already contained in the soil, and causes those portions which are most advantageous to plants to be developed in the greatest quantity. For the same reason, it tends to accelerate the exhaustion of the soil; which, consequently, is rendered more sterile if it be not speedily ameliorated. It is this action which makes it so necessary, where lime is used for the purpose of improving the land, to manure it at the same time with a quantity of dung or some such matters. But it must also be allowed that carbonate of lime exerts a similar influence upon organic bodies, especially where putrefaction and decomposition have already commenced. The carbonate also appears to possess, although in an inferior degree, the power of acting upon certain combinations of hydrogen, nitrogen, and carbon, taking up a certain portion of them, and thus weakening or perhaps destroying their original state of combination.

One of the most remarkable properties of lime—a property which renders it so eminently useful as a building material—is, that it hardens when mixed with certain stony substances and made into a fluid paste, and forms with them a matter which possesses the firmness of rock. Mortar, made of sand and slaked lime, soon dries when exposed to the air. This composition not only possesses great cohesion in itself, but also adheres firmly to other stony substances, and serves to unite them together. This cohesive power arises from the strong affinity which

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soap, decomposes it, and forms a soap of lime; which, being insoluble in water, forms a white curdy matter which swims upon the surface of the water. Waters which owe their hardness to the presence of either sulphate of lime (gypsum) or carbonate of lime (chalk), always produce this effect upon soap.

exists between silica and lime. A mixture of lime and water presents numerous points of contact to sand, stones, and other kinds of hard substances which are chiefly composed of silica, and thus its cohesion with them is strengthened; the water evaporates, and by so doing still further augments the cohesion; finally, the lime absorbs carbonic acid from the air, and thus undergoes a sort of crystalization, which increases to a yet greater extent both its own cohesion and its adhesion to bodies of a silicious nature.

Lime cannot, even by the most intense heat, be made to fuse, unless it is mixed with other substances. Too great a degree of heat does, however, produce a certain change in its properties, rendering it insoluble in water and unfit for making mortar. This tendency is well known to those who have the management of limekilns, and they cautiously endeavour to guard against it. When it has undergone this alteration, it is called *dead* or *burnt lime*. This condition is that of a species of vitrification or agglomeration; the cohesion of the integral parts is augmented, and the affinity for water is greatly diminished by this change. But lime may be completely fused when mixed with silica.

Lime has a powerful affinity for acids, and for most of them its affinity is even greater than that of the alkalies properly so called. It attracts carbonic acid more powerfully than potassa, soda, or ammonia do, and can even deprive these substances of the carbonic acid which they may possess; it is, therefore, employed as the best means of converting the alkaline carbonates into caustic alkalies. It has, also, a greater affinity than the pure alkalies for the sulphuric nitric, muriatic, and phosphoric acids; the alkalies, therefore, cannot decompose the compounds of lime with these acids.

When acids are brought in contact with calcined lime that has been previously slaked, the combination takes place promptly and without effervescence. If the acid used be the nitric or muriatic, both of which form soluble neutral salts with lime, the latter is dissolved by the liquid and ceases to be visible, the fluid becoming perfectly clear. But if the compound be a neutral salt which is insoluble, or, at all events, difficult of solution, as is the case when sulphuric or phosphoric acid is used, the lime remains suspended in the liquid, and separates anew after having entered into combination with the acid.

When liquid acids mixed with water are poured upon lime which has been calcined, but not slaked, a disengagement of heat takes place, which causes the liquid to effervesce. This effect is due less to the action of the acids than to the absorption or crystalization of the water, and is very different from the effervescence which accompanies the action of acids upon the carbonate of lime.

Carbonate of lime dissolves in acids quite as readily as calcined lime; while this solution is going on, carbonic acid escapes in the form of gas. This gas rises to the surface of the fluid in the form of bubbles, and causes a violent effervescence. As this phenòmenon always accompanies the solution of carbonate of lime in an acid, it has been regarded as a certain indication of the presence of that substance in any earthy body. If effervesence takes place when an acid is poured upon the earth, the presence of lime may be inferred; but this evidence must not, however, be regarded as conclusive or unexceptionable. If an addition of acid causes no effervescence, it may then be reasonably believed that the earth does not contain carbonate of lime, at least in any appreciable quantity; but the contrary does not so necessarily follow, because the same phenomenon is produced by the disengagement of carbonic acid from the carbonate of magnesia or iron when acted upon by acids; the effervescence attributed to the carbonate of lime may, therefore, be caused by the presence of one of these substances.

When calcined lime combines with acids, it loses the causticity and alkaline properties, and the acids themselves also lose their distinguishing characteristics. The effect is the same whether it be the carbonate or calcined lime which combines with the acids. In either case the resulting compound is a simple combination of lime with the acid employed.

The neutral salts which lime forms by its combination with acids, exhibit different properties with the acids by which they were produced; they are, also, sensibly different from those which the same acids form with other earths. We shall not here attempt to enter into a minute examination of more than one of these salts, viz., the sulphate of lime, or gypsum.

Among the calcarious minerals essentially composed of carbonate of lime, we distinguish the following:—

1. *Calcareous-spar.* Is composed entirely of carbonate of lime; it is found in crystals or in masses in the interior of strata, and not unfrequently serves as a matrix for metallic ores. Its crystals vary between the forms of the prism, the pyramid, the rhomboid, &c. Calc-spar is more or less transparent, colourless, and breaks into rhomboidal fragments. The transparent rhomboidal crystals of calc-spar have the property of multiplying the objects seen through them.

2. *Limestone.* Whole mountain chains are found composed of this rock; it is extracted in order to be calcined and converted into lime, a purpose for which it is peculiarly adapted. It is hard, and usually of a greyish hue, inclining to red or yellow: occasionally it is found variously coloured. The grey variety is the best. It is, moreover, distinguished by the form of its fracture; some kinds of limestone having an earthy, some a scaly, and others a schistous fracture. Limestone always exhibits a greater or less degree of hardness, but is never sufficiently hard to emit sparks on being struck with steel. It does not, naturally, possess either lustre or transparency, but sometimes acquires the former from polishing. Limestone often exhibits impressions and petrifications of testaceous animals: sometimes it is impregnated with bituminous substances, and, in that case, on its fragments being rubbed together, it emits a fetid odour similar to that of garlic. This variety is called *stinking stone*, or *swine stone*, or *lapis suillus.*

Limestone is not generally so pure as calc-spar, and it often contains oxide of iron, alumina, and silica. According to Simon, one hundred parts of Rüdersdorff limestone contain—

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|---|---|
| Chalk | 53·0 parts. |
| Carbonic acid | 42·50 |
| Silica | 1·12 |
| Alumina | 1·0 |
| Iron | 0·75 |
| Water | 1·63 |
| | 100·0 |

According to the same author, Swedish limestone contains rather more silica, alumina, and oxide of iron, and likewise a little of the oxide of manganese.*

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* The common varieties of lime, used by the English farmers, are procured by calcining either chalk or limestone. Such lime is therefore, rarely, if ever, chemically pure, for it almost always contains a portion of silica (flint), alumina (clay), and some red oxide of iron. These, however, are not often present in sufficient quantities to influence the fertilizing powers of the lime to any material extent, as will readily be seen by the analysis of the limestones, and the chalk usually employed by the lime burners.

| | |
|---|---|
| Carbonate of lime | 95·05 parts. |
| Water | 1·63 |
| Silica | 1·12 |
| Alumina | 1·00 |
| Oxide of iron | 0·75 |

100 parts of common chalk contain—

| | |
|---|---|
| Lime | 56·5 parts. |
| Carbonic acid | 43·0 |
| Water | 0·5 |

united with various small proportions of the other earths. There is also a very considerable proportion of lime made in the North of England from the magnesian limestones, called by the Yorkshire farmers " hot lime," all of which differ considerably in composition; that from Sunderland containing in 100 parts—

| | |
|---|---|
| Carbonate of lime | 56·8 parts. |
| Carbonate of magnesia | 40·84 |
| Clay, water, &c. | 2·0 |
| Oxide of iron | 0·36 |

This " hot lime," which is well known by the farmers in the neighbourhood of Doncaster, and other parts of the north of England, can only be applied in limited quantities, for the calcined magnesia of the limestone remains for a considerable period in its pure caustic form, without absorbing carbonic acid gas from the atmosphere, and in this state its effect is very pernicious to many kinds of plants. It is only when pure, however, that magnesia is prejudicial to vegetation: by exposure to the atmosphere, it gradually and slowly absorbs carbonic acid gas, becomes carbonate of magnesia, and in this state forms a part of many cultivated plants. Some of the most fertile soils of our island, in fact, contain it, in this form, in considerable quantities.

The action of the fire upon the chalk and the limestones merely deprives them of their water and carbonic acid gas, or fixed air. The farmer must not fall into the very common error of supposing that anything is *added* by the

Marble is a species of concrete limestone, which is only distinguished from the others by the small admixture of foreign bodies which it contains, by being considerably harder and finer grained, and by the variety of its hues, which latter often give to it a very beautiful appearance.

3. *Chalk.* This is a species of concrete lime of different degrees of hardness, meagre to the touch, slightly inclined to stain or soil whatever it comes in contact with, and capable of being easily reduced to powder. It is of a white or yellowish white colour, and derives its name from the Isle of Crete or Candia, in which large quantities of very fine chalk are found. It may also be procured from other countries, in some of which there are large hills composed entirely of it, as, for example, in England, Denmark, France, &c. Chalk may be employed in the manufacture of lime, and is also in daily use for various other purposes. There are other fossils which are often called by the same name, but which, nevertheless, must not be confounded with this substance. Spanish chalk is a species of stealite, which belongs to the class of magnesias. Black chalk is of the schistous species.

4. *Pulverulent lime.* In hills, plains, and low grounds, a species of friable white earth is often found, bordering in hue more or less on yellow or grey, and which is principally composed of carbonate of lime. It is meagre to the touch, possesses a small degree of consistency, and when impregnated with water does not form a concrete mass. We call it pulverulent or earthy lime, but in many places it is known as *marlly lime,* and is sometimes denominated *marl.* It consists of too great a proportion of lime, containing at least ninety parts of it in a hundred, to admit of its being classed among marls. It is moulded into the form of tiles in order to be reduced to quick lime by calcination, but it may be advantageously employed as a manure without being submitted to the action

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fire to the lime; on the contrary, it loses very materially in weight, by being deprived of its carbonic acid gas, a loss, however, which it gradually recovers by exposure to the atmosphere, which always contains this elastic vapour.—*Johnson Farmer's Encyclo.*

of fire, and the more so, as the simple action of the atmosphere is sufficient to reduce it to powder. It is, therefore, of great importance to the agriculturist, as in all probability its origin is the same as that of the kind we are now about to mention.

5. *Lamellated* or *shell lime.* This variety is sometimes found in mountains, but more frequently in plains, covered by a thick layer of black marshy earth. On the surface there is usually a layer of shells, which, as we penetrate deeper, exfoliate into flakes: underneath these is a layer of loose friable lime; and further down still, a species of lime almost as hard as a stone. It is here easily perceptible, that this substance has been formed from the remnants of testaceous animals, and that it has gradually become hardened into stone.

6. *Stalactites* and *calcareous crystalized concretions.* These varieties have been produced by the droppings of water, which has dissolved a great deal of carbonate of lime by means of the carbonic acid which they contain. In proportion as this acid has become evaporated, the lime has been deposited and hardened on itself, or on any other bodies which it met with in its descent. Stalactites of various remarkable forms are frequently found, principally in grottoes, and especially in those called Bauman's or Biell's Höhle, in the Hartz mountains, in the Gotto of Antiparos, &c.

The calcareous sandy-stone is a concretion which is formed by the depositions of water. It is found at Carlsbad in Silesia, among the Hartz mountains, and in almost all places where there are calcareous mountains. Sometimes it assumes the form of little balls, adhering to one another, which are either hollow or contain a kernel of sand. They are called *stones of peas*, or *fossil lentil.*

### *Gypsum, or Sulphate of Lime.*

Of all the various concretions which are formed by combinations of lime with different acids, we shall only enter into an examination of one, namely, that which results from the union of lime with sulphuric acid, and is commonly called gypsum, but which is known to scientific men by the name of sulphate of lime. This body is perfectly insipid, and can with difficulty be dissolved in water; when it has been purified, either by some combustible matter or metallic oxide, it is always of a whitish colour. According to Buckholtz, it takes 461½ parts of water to dissolve one part of gypsum, but the data with regard to this point vary considerably. Buckholtz also states that the dissolving powers of warm and cold water on this substance are almost equal; but other authors assert that warm water dissolves the greatest quantity of it. The difficulty in dissolving gypsum is the reason that it can never be produced in the form of crystals. The solution of it only produces a few crystaline grains. It is also on this account that large quantities of lime, dissolved in sulphuric acid, cannot be obtained in a liquid form, and that it always remains behind in the filter. If sulphuric acid, diluted with water, is poured upon lime, a combination certainly takes place; but the gypsum which results from it presents itself in the form of a white indissoluble powder, only a very minute portion being held in solution by the fluid.

The solution which contains this small portion of gypsum exactly resembles pure water; it has, however, a slight taste, although the powder itself is absolutely insipid. This taste is not easily described: it is remarked in most water that contains a solution of gypsum, and it is then called *hard* water. If this solution be gradually evaporated, gypsum will continue to be precipitated during the whole of the process, for the remaining fluid will only retain that quantity which it can hold in solution. Water containing carbonic acid dissolves a much greater portion of gypsum than pure water; but, in proportion as the acid evaporates, the substance held in solution will be precipitated: thus, if the fluid be exposed to the influence of the atmosphere, it loses the chief part of its gypsum; and if it be boiled, the whole of the substance will be found deposited at the bottom of the vessel. Waters impregnated with gypsum, or in other words *hard-waters*, are totally unfit for many purposes; but when applied to the irrigation of meadows, the effects are ameliorating and fertilizing.

According to the experiments made by Buckholtz, gypsum is composed of thirty-three parts in a hundred of lime, forty-three of sulphuric acid, and twenty-four of water of crystalization. There may, however, exist varieties of this substance which contain different proportions.

When exposed to the atmosphere, gypsum does not lose its water of crystalization; but if submitted to the action of fire, the water is immediately evaporated, without, however, the gypsum being cracked or broken. It loses in weight all the water which it previously contained. In order to produce this effect, it is not necessary that any very great degree of heat should be applied; it may even be inferior to that which is requisite to effect the calcination of lime. When gypsum which has been broken into moderate-sized pieces is passed through the fire, it becomes calcined, and is at the same time rendered perfectly soft, so much so that it can be easily crushed between the fingers.

Gypsum which has thus been deprived of its water of crystalization by the action of fire, is termed calcined gypsum or plaster. When in this state, it may be used as mortar, or formed into moulds or casts. When the plaster is reduced to a very fine powder and mixed with water, it rapidly absorbs that fluid and solidifies and combines with it, the same as with the water of crystalization. In this change a disengagement of heat takes place similar to that which results from the combination of lime and water; but the elevation of temperature is not so sensible in this instance, because the union does not take place so promptly. If more water is added than the plaster requires for the purpose of crystalization, the mixture remains for some moments in the form of a thick paste, but eventually unites into crystals, and forms a compact mass. It is this property which renders it so useful as a stucco.

Calcined gypsum, when exposed to the atmosphere, gradually absorbs moisture, which it combines with in the form of water of crystalization, and thus increases in weight, but at the same time loses its faculty of effervescing when mixed with mortar, and also its utility as mortar. When this is the case, it can only be restored to its pristine state by being calcined afresh; when this has been done, it is once more available for mortar.

If during the process of calcination gypsum should be exposed to too great a degree of heat, it undergoes an alteration similar to that which lime experiences in like circumstances. When burned, it no longer effervesces when brought into contact with water, loses its beneficial effects as a manure, and cannot be made into stucco.

Gypsum can only be fused by means of a very intense and prolonged degree of heat. When it has undergone this process, it not unfrequently evolves light when placed in a dark place. The heat does not effect the decomposition and separation of the sulphuric acid from the lime, it only deprives the gypsum of its water: this substance is only decomposed when, along with coal or vegetable bodies, it is absolutely ignited; then only does its sulphuric acid become deprived of oxygen, and a portion of the sulphur thus separated is evaporated, while the rest remains combined with the lime, thus forming sulphuret of lime or liver of sulphur. This will account for the sulphurous smell which always prevails in the neighbourhood of gypsum kilns.

It is probable that a similar combination is effected, though much more slowly, at a less elevated temperature, when the gypsum is united with bodies impregnated with carbon, and which are in a state of putrefaction; a portion of the beneficial effect of gypsum in ameliorating land, arises from this circumstance. When water impregnated with gypsum is foul or muddy, it gives out a fetid sulphurous odour. Fourcroy attributes the bad smells which prevail in some towns in the neighbourhood of Paris to this quality.

Lime has a greater affinity for sulphuric acid than the alkalies have, and, consequently, gypsum cannot be decomposed by these substances; but alkaline carbonates easily effect a complete decomposition of it by means of a double combination. If, for example, powdered gypsum is boiled in a solution of carbonate of potassa, this latter combines with the sulphuric acid, while the lime unites with the carbonic acid. The lime then passes in the form of a white powder into the state of carbonate of lime, while the alkaline sulphate is dissolved in the fluid.

The gypsum which is met with in the mineral kingdom sometimes constitutes entire mountains. It is found under various forms, sometimes as a pulverulent body, at other times in large masses, and occasionally crystalized. The following are some of the kinds most frequently met with:—

1. *Powdered gypsum, celestial farina.* This gypsum is pulverulent; it is found in the neighbourhood of gypseous rocks, from which it has been separated and reduced to powder by the action of water. In some places it is seen issuing from the earth. At a period of scarcity and famine, this substance was supposed to be meal or flour sent down from heaven; it was gathered up, mixed with real flour, and made into bread, which, as might have been expected, was not calculated for the sustenance of mankind, but which nevertheless was not so immediately injurious as many persons may be disposed to believe.

2. *Common compact gypsum.* This variety is found in large masses in secondary mountains. It is not very hard, breaks with a crackling sound when crushed between the teeth, cannot be polished, and is so tenacious that it is scarcely possible to reduce it to powder. It is met with of different colours, but is generally either grey or white. Alabaster belongs to this species, and bears the same relation to gypsum that marble does to lime; it is a semi-crystalized stone, capable of receiving a high degree of polish, and is used for various kinds of sculpture, vases, statues, &c. Sometimes it is beautifully variegated with all kinds of colours, which are produced

by metallic oxides. Alabaster is not capable of so high a polish as marble, because it is not so hard or compact, and is apt to become deteriorated by exposure to the air.

3. *Gypseous spar*, or *crystalized gypsum.* This variety is frequently found in places where there are considerable quantities of gypseous stone or compact gypsum, and is closely combined with it. It is more or less transparent, variously shaded, and may be split with a knife into thin, soft, and transparent flakes.

The kind called *glacies mariæ* also belongs to this variety, which is found in large rhomboidal crystals, and can easily be cut. Sometimes the gypseous spar is met with in large crystals, bearing the form of tables or pyramids. This substance is likewise very tenacious, and can with difficulty be powdered.

4. *Gypseous stalactites* have originated in the same manner as the calcareous stalactites; that is to say, they have been formed by the depositions of carbonated waters which held a considerable quantity of gypsum in solution. Sometimes gypsum and carbonate of lime are found mixed together. These calcareous gypsums effervesce when brought in contact with acids.

There are many waters which hold gypsum in solution. This is frequently the case with spring water, which is then called hard or rough, and is unfit for various purposes, and especially for the distillation of brandy. Gypsum is occasionally met with on the surface of the soil in combination with lime or clay; it is likewise found in the ashes of certain vegetables; but in all probability it does not exist in plants, but has been produced during the combustion by the combination of the sulphuric acid with lime.

## MARL.

This substance, which is of so much importance in agriculture, has long been known to many farmers as an active agent in ameliorating and increasing the fertility of land. In many countries there are whole districts which have formerly been improved by the use of marl. Its properties in this respect were known and recognized by the Romans; but it is only lately that the marling of land has attracted general attention, and there are still many agriculturists who have not a distinct idea of this substance, although a small amount of chemical knowledge is requisite to enable them to distinguish it from other earths. It is this total ignorance of the nature of marl which frequently causes them not only to deny its beneficial properties, but even to decry it; and hence it is that they pretend to have seen such evil consequences to result from the use of it. There is no doubt that the substance which they applied to their land as marl was some more tenacious and ferruginous clay, or some other kind of earth which did not agree with the soil. We shall hereafter speak of marl as a manure, at present we have only to explain its nature and the manner in which it generally exists in the soil.

Marl is a combination of carbonate of lime and clay. These two bodies are usually found in so complete a state of amalgamation that it is impossible to distinguish the particles of one from those of the other either with the naked eye or with the aid of a microscope. The agents by means of which this union is effected, have not as yet been discovered; for when clay and lime are mixed together artificially, the substance formed is very different from natural marl; for example, it does not possess the faculty of losing its aggregation when exposed to the influence of the atmosphere, and crumbling to dust like natural marl.

The proportions in which clay and lime are found combined in marl, are many and various. Sometimes there are equal quantities of each of these substances, while in others the one predominates considerably over the other. Nature does not seem to have prescribed to herself any rule for the regulation of the proportions in which they shall be united. Marl has been classed under different heads, according to the proportions of lime or clay of which it is composed. The classification adhered to by *Andrea*, in his work on the various species of earth in

Hanover, is decidedly the best, and is the one generally adopted throughout the greater part of Germany. According to this author, marl is simply a combination of nearly equal parts of clay and lime. If the former predominates so much as to constitute nearly or quite two-thirds, the mixture is then called *argillaceous marl;* and if the proportions of clay are still greater, so that there are three parts of that substance to one of lime, it is then called *calcareous* or *marly clay.* On the other hand, if the lime predominates and forms nearly or quite two-thirds of the mixture, it receives the name of *calcareous marl;* and when the quantity of this substance is still further increased, so that it constitutes three parts while there is but one part clay, then the combination is termed *argillaceous lime.*

Marl in all its varieties is met with in a great number of countries. Indeed there is no doubt that, if carefully sought, it will be found in most places; it has been proved that almost all the inferior strata of the soil contain some portion of it. There are very few countries in which it does not exist, or in which it is too deeply imbedded in the earth to be extracted with any degree of profit. It is nowhere met with in such abundance as in hilly or mountainous countries, in the neighbourhood of stratiform or secondary mountains, of which it constitutes the principal part of the inferior layers of the soil, and is disposed in continuous banks. It is not so easily found in dry, flat, or marshy countries; and it is there deposited in heaps at unequal distances and at various depths. The existence of a stratum of marl beneath the soil may generally be inferred when certain plants are found upon the surface, viz., *tussilago* or *coltsfoot (tussilago farfara), tussilago alpina, yellow flowered sage (salvio glutinosa), meadow sage (salvia pratensis)*, all which flourish much better in marly than in any other soils. It is not the presence of the plants alone which may be regarded as indicative of the existence of marl; wherever they are observed to multiply and flourish with peculiar richness of vegetation, they will generally serve as guides to the discovery of marl.

The presence of *black medic* or *nonsuch (medicago lupulina)*, on a soil which has not been manured, may, in my opinion, be considered as an indication of marl. This substance, or at any rate marly clay, may generally be found under briars. When marl exists in heaps at a certain depth below the surface, it frequently shows itself at the edges of ravines or in uneven roads, from which the layer of earth which covered it has fallen or has been rubbed off. These heaps of marl are frequently again covered by clay; wherever this latter body is found intermingled with grains of lime, there is every probability that marl will be met with if we penetrate sufficiently deep into the soil. The beds of marl are not by any means equal in thickness throughout their whole extent; this observation applies particularly to argillaceous marl. There is generally less of lime in the superior than in the inferior strata; and, usually, the lower we descend the more calcareous does the bed become.

Both clay and lime contribute to constitute the properties of marl; in this mixture these two kinds of earth form a mutual exchange of their reciprocal qualities. The tenacity and unctuous quality of the clay is tempered by the lime; while, on the other hand, the harshness or stiffness of the lime is softened by the admixture of the clay. According as one or the other of these substances predominate, so do the characteristics of it predominate in the marl.

Marl, properly so called, is composed of equal parts of clay and lime, and cannot be assimilated to either the one or the other of these substances; the properties of both are amalgamated in equal proportions. Argillaceous marl or calcareous clay approaches more to the qualities of clay: therefore, when impregnated with water, it becomes unctuous, more ductile, emits a clayey odour, and in drying re-unites into hard clods, which are, however, malleable. Marly clay, when moistened, is frequently more difficult to work than clay deprived of marl; but it is much more easily dried. Calcareous marl and argillaceous lime assimilate more to lime, when dry: they are less rough to the touch when moist, they have less cohesion; and when the fragments are dried, they can easily be crushed between the fingers. It depends a great deal upon the nature of the clay which enters into the composition of these marls, whether they are rich or poor. A rich clay requires the addition of a larger quantity of lime in order to correct its defects; while in a poor clay a much smaller proportion will produce the same effect. Two varieties of marl are often met with, one of which, in its external appearance greatly resembles argillaceous marl, and the other is like calcareous marl, and yet both of these contain equal quantities of lime; but the former is composed of rich tenacious clay, while the latter, on the contrary, consists of clay of a poorer quality. The nature of the latter substance has also a considerable influence upon the qualities of the marl.

Marl is of different colours; being sometimes white, yellow, brown, grey, violet, red, blue, or black. These colours are produced partly by the oxides of iron or manganese which it contains, and partly by combustible matters, as bitumens or humus. Those varieties of marl which contain only the latter are usually grey, bluish, or black, and combustion renders them white. Those which are impregnated with bitumen, give out the odour peculiar to that substance when heated or when pieces of it are rubbed together. The colour of the marl is a very uncertain indication: at most, it can only enable us to appreciate the quantity of combustible matter or metallic oxide which it contains: it will not serve to distinguish the nature of the marl, or the proportions of clay and lime which compose it. Marls of the same colour frequently differ essentially in the proportion of their elements; while others, which in external appearance are perfectly dissimilar, show no differences in point of composition.

With respect to the consistence and contexture of their parts, the marls differ essentially among themselves.

Sometimes they are soft to the touch as dust, or possess so slight a degree of consistency that they may easily be crumbled to pieces between the fingers; while others are hard as a stone. The former are called "earthy," and the latter "concrete" marls. This latter species is still further distinguished by its contexture: it either has a schistous fracture, and is composed of flakes laid over each other, which can be separated with a knife; or it has no uniform layers, but when broken, flies into irregular pieces. The former of these is called "schistous," and the latter "stone" marl. No decisive conclusions with respect to the nature and composition of marl can be deduced from these differences of conformation. Sometimes concrete marl contains a superabundance of marl, and at others a superabundance of lime; and when this is the case, it bears a greater resemblance to limestone. If we find a marl belonging to the species which we call calcareous, we must not, on that account, infer that it contains a superabundance of lime; for it is possible that the clay was naturally poor, so that the marl had not a great deal of consistence. When water is poured upon marl, that fluid penetrates with greater or less facility into all the pores, destroys the cohesion of the parts, separates them from one another, and reduces them to a fine powder. This is one of the essential properties which serves as the first distinction of marl, and by means of which this substance ameliorates the soil, by mingling completely with its surface. The air shows itself in bubbles which rise in the water, sometimes making a slight noise and occasioning a kind of effervescence. It certainly cannot be admitted as a principle, that any kind of earth which loses its aggregation in water must necessarily be marl, since very poor clays are affected in the same manner; but if any kind of earth is not spontaneously reduced to powder by the action of water, we may feel convinced that it is not marl. Every kind of marl, even that which is called "stony," becomes soft and pulverised in water. This substance likewise loses its cohesive attraction when exposed to the humidity of the atmosphere, and is reduced to powder in the same manner as by the action of water, only the process occupies more time. It is this property which renders marl so useful as a manure. It is not at all necessary to pulverise it before it is put into the soil which is to be ameliorated, that operation may be left entirely to the influence of the air; the humidity of the atmosphere penetrates into the marl deposited in the soil, and reduces it to powder. Frost contributes materially towards effecting a total division of the particles, and, indeed, with concrete and tenacious marls, its assistance is often absolutely necessary, and this is the reason that these marls are generally laid on before the approach of winter. The moisture which the marl has absorbed is expanded by the frost, and forces the parts asunder.

The time which is required to reduce marl spontaneously to powder by the action either of air or water, depends in a great measure upon the proportion of clay which this substance contains in its composition, and upon the degree of hardness and of the cohesion which exists between its parts. Pure compact limestone will not resolve into powder, neither will pure solid clay. If, therefore, lime forms the predominating ingredient in marl, this latter does not lose its aggregation; the same effect is evident where clay forms the chief constituent part, or, at any rate, the division is effected very slowly. In order that the cessation of cohesion may be promptly brought about, is is evidently necessary that there should be a certain proportion of these two substances, and the degree of this proportion will depend entirely upon the nature and the richness or poverty of the clay.

In marls composed of similar clays, but which contain proportionately different quantities of lime, the substance which, properly speaking, ought to be called marl is that which is most easily deprived of its cohesive qualities; and, on the other hand, calcareous and argillaceous marls are those which oppose the greatest resistance to the action of fire, water, and air. The division is never so slowly effected as when the parts have acquired the hardness of a stone, as in the case of stony marls; while among the number of concrete marls, those which are of a schistous nature lose their aggregation much sooner than those which are found in homogeneous masses.

Marl produces a very great effervescence when brought into contact with acids or acidulated fluids. If the latter are poured upon this substance, they combine with the lime; while the alumina remains untouched, so long as the acids have any lime left to dissolve: it is only when all the lime has been absorbed and the acid still remains unsaturated, that it attacks and dissolves a small portion of the alumina and of the oxide of iron.

It is well known that carbonate of lime cannot be fused without the agency of some other substances, and that clay is scarcely vitrified even by the hottest fire; but that if these two earths are united, they may then be melted without difficulty: marl, therefore, is a substance capable of being fused and vitrified. It does not require any great degree of heat to melt it, and this is the reason of its being used for the purpose of separating metals and facilitating the fusion of metallic gangues.* It is sometimes used to procure iron.

Marl is occasionally found intermingled with other substances, which do not, properly speaking, belong to its composition. Of these, magnesia, sand, and gypsum are most frequently met with. Magnesia is often found in marl, and especially in that kind the beneficial effects of which as a manure are most evident. It also exists there in a state of carbonate, effervescing when brought in contact with acids, and dissolving in them. These circumstances have caused magnesia to be frequently confounded with lime when the marl is only superficially examined. But as we are as yet ignorant of the effect which it produces, it is very important that it should be properly distinguished and inquired into. Marl which contains magnesia is called "magnesian marl," and it is still furthur distinguished by the terms "argillaceous" or "calcareous magnesian marl," according as the clay or lime predominates. This substance always contains a small portion of sand; when the quantity is considerable, the marl which contains it is called argillaceous or calcareous sandy marl. If the proportion of sand amounts to sixty, seventy, or eighty parts out of a hundred, then the substance is called "sandy marl." A slight admixture of sand in marl is highly beneficial to that substance, causing it more rapidly to part with its aggregation. Marl likewise contains some portion of gypsum, which occasionally shows itself in small crystaline veins, and is rendered still more susceptible when the marl is heated: the presence of gypsum probably ameliorates the marl, and renders it more friable; but we have not, as yet, any certain information on this point. If the marl contains considerable quantities of gypsum, it is then called argillaceous, or calcareous gypseous marl.

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* "Gangue," a German word, signifying the rock to which the metal or mineral is attached in the bowels of the earth.

The external appearances under which marl is found are many and various. The following are some of the principal varieties, not classed according to their internal composition, but according to their external appearance:

(*a*) *Stony*, and frequently *schistous marl*. This kind is, in most cases, tolerably friable while in the earth; it is only when exposed to the atmosphere that it hardens and changes colour, and then the lapse of two or three years is barely sufficient to deprive it of its aggregation. This marl is often very calcareous, and so much resembles limestone that it is sometimes calcined in order to be made into lime, or used in its rough state as marl. But the lime produced from this substance is impure and bad in quality. This marl occasionally has the hardness and all the other appearances of common lime; however, the proportion of alumina and silica contained in it is usually greater than in lime.

(*b*). *Argillaceous* or *clayey marl*. We have already mentioned the distinguishing characteristics of this variety.

(*c*). *Lamellated marl*. This kind is only found in thin layers.

(*d*). *Shell-marl*, on the surface of which the remains of marine and land shells are frequently found. Further down it resembles dirty chalk, and lower still it is sometimes crystalized and stony. This marl is hardly ever found except in plains, under turf, peat, black or marshy earth, and in places where water has formerly been stagnated. It is principally composed of lime; and has, therefore, been called marly lime, and is frequently calcined and used as lime. It is separated by the action both of air and water; and when mixed with a suitable proportion of that fluid, although without being calcined, it is used for bleaching. When applied to land, this marl does not act so promptly as might have been expected; it often contains phosphoric acid.

The first variety (*a*) is hardly ever found excepting in mountainous countries; the second (*b*) is generally met with in hills covered with brown clay, in which briars have taken root. Sometimes these hills are anything but fertile, even when the clay which is on the surface contains calcareous particles. The marl appears to have rapidly consumed the humus, or perhaps this latter substance having been rendered more soluble by the marl, has been carried away by heavy rains. But the fertility of these places will soon be restored if they are abundantly manured. I state this fact in order that agriculturists may not be prevented, by the apparent sterility of the land, from digging it up in order to discover the marl. The two last varieties (*c* and *d*) are only found in flat grounds and in plains.

## MAGNESIA.

This earth is less diffused throughout nature than either of the preceding. It is never met with pure, but always mixed with other earths and combined with acids. Several minerals contain portions of it: springs, rivers, the sea, and salt water also contain it; but it is then principally combined with the muriatic and sulphuric acids. It also enters into the construction of animal bodies, and is then generally united with phosphoric acid. The ashes of most vegetables contain more or less of it; it sometimes forms a very considerable constituent part of the layer of vegetable mould, and of that marl which is best adapted for the purpose of manure. This earth, which has not long been discovered and distinguished, has latterly awakened great attention as regards its relation to agriculture. Bergmann and other authors have represented it as very fertile; but Tennant, an English chemist, observes, that some calcined lime which had been used to ameliorate land had produced quite a contrary effect; and on being analyzed, it was found to contain a great deal of magnesia; and thence he arrives at the conclusion that the effects of this earth are always prejudicial. In its natural state it rather resembles carbonate of lime in all its points. Lampadiers found it to be very favourable to the vegetation of barley; and Einhoff, when analyzing a peculiarly ameliorating marl, found it to contain twenty parts in a hundred of magnesia.

Carbonate of magnesia is both insipid and inodorous. When moistened and mixed with water, it forms a consistent matter, which soon dries up. With regard to its disposition to retain water, it may be assimilated to carbonate of lime, and, indeed, its relations to water are generally the same as those of that substance. Carbonate of magnesia is insoluble in pure water; it can only be dissolved in water which has been impregnated with carbonic acid gas.

Pure magnesia, freed from carbonic acid, is easily distinguishable from lime. It is neither caustic nor alkaline like that substance; it does not emit any heat when mingled with water; the paste which results from this mixture does not harden in drying; and when sand is combined with it, a mortar is not produced. In fact, it appears to absorb water and appropriate it, but without depriving it of its fluidity. It effects a very slight alteration in blue vegetable colours.

The following are the fossils which contain magnesia, and which are greasy and soapy to the touch:

1. The *serpentine-stone*. This is a hard, fine-grained stone of a dark green or grey hue, occasionally striped or spotted with red. It is found in beds which sometimes

constitute entire mountains. The best quarry of this kind of stone in Germany, is at Topplitz, in Saxony, where an almost incredible quantity of it is worked. It is manufactured into snuff-boxes, fancy boxes, vases, candlesticks, mortars, and all kinds of cups and vessels by means of turning machines; and afterwards polished with fine freestone. The constituent parts of this substance are magnesia, silica, and oxide of iron.

2. *Talc*. This substance has a lamellated fracture: it is very greasy to the touch, and is sometimes found in the form of earth; at others, under that of stone. The former is composed of unctuous and slightly luminous parts, and is in general nearly or quite white; the latter, on the contrary, is harder, and may be divided into thin flakes, which frequently have the brilliancy of gold or silver, on which account it has been called *argentium*. It is used for the purpose of diminishing friction in machinery, and is one of the best agents which can be employed, being far preferable for that purpose to either soap or oil, because it does not occasion any dilatation of the wood, and it also preserves the metal from the almost insensible effect occasioned by friction.

Talc is composed of forty-four parts in a hundred of magnesia, and fifty-six of silica and alumina.

3. *Lapis ollaris*, or *soap-stone*, is a variety of talc; it is greyish, grey, or deep green, and may be turned and made into all kinds of vases, &c. It is principally found in Switzerland.

4. *Soap-rock* or *earth*, is a species of opaque smooth stone, as unctuous as soap, which may be scraped off with the finger nail, and stains or soils every object with which it comes in contact. There are several varieties of it, some of which are soft, and others compact; the latter is also called Spanish chalk, because it was originally brought from that country. By means of it, figures or words may be drawn upon glass; and, although all traces of the writing vanish when the glass is washed, they reappear as soon as it is exposed to a moist temperature. It is also used for drawing designs for embroidery, and is

found in several parts of Germany, and particularly in Bareuth.

5. *Amiantus*, or *asbestos*. This kind of stone is composed of a filaceous tissue, the filaments of which are either arranged in parallel lines or transversely; in the former case, these threads are flexible, and it is then called "amiantus." It is generally of a whitish hue, bordering upon green, or a greyish green. Several other species are likewise found, which are called "*salamander's hair*," "leather fossil," &c., on account of some resemblance or fancied resemblance which they bear to the substances from which they derive their names. This stone prevails in Saxony, Silesia, Bohemia, Hungary, and Sweden. Those manufactures of incombustible linen, paper, and wicks for candles, which at one time appeared so incomprehensible, are formed of amiantus. In order to make linen, the thin flexible threads of the amiantus are spun with flax; it is then woven, and the cloth passed through the fire. When paper is to be made, the filaments are pounded and bruised until they are reduced to a pulp: all the usual processes attendant on paper-making are then gone through.

6. *Alcyonium*, or *froth of the sea*. The bowls or heads of those pipes which are so much prized are made of this substance. There formerly used to be some doubt with regard to its origin: it was thought to be a marine production; and hence derives its name: but it is known now to every person to be obtained from the village of Klitschik, not far from Conia or Iconium, in Natolia. It is found in veins in the cavities of a grey calcareous schist, a little below the surface of the soil. When first extracted, it resembles a soft paste, which, however, soon hardens when exposed to the air; it is made into the heads or bowls of pipes, and sold at Constantinople, where these are coloured, or baked in oil or wax, and then exported to Germany, where they are worked afresh: pipes of a second-rate quality are made from the fragments of those which are broken. Notwithstanding its softness, this substance possesses a great deal of con-

sistency, and is less liable than most of the other fossils to snap to pieces. According to Wiegleb it is composed of equal parts of magnesia and silica: he asserts that it may be found in Spain, not far from Madrid; in Hungary; and in North America.

## IRON.

We have already stated when speaking of clay that the soil frequently contains iron, which presents itself under various forms. We meet with it as an oxide totally free from acids, and under various degrees of oxidation, of a white, green, black, or red hue, and intimately combined with alumina; in this state it imparts all those different shades of colour to clay which that substance is frequently found to possess. We do not as yet know exactly what influence it has upon vegetation, or whether or not it tends to ameliorate the soil. In many kinds of clay, we find oxides of iron in a state of carbonization: when in this state, it does not appear to have any influence at all on vegetation; and, at all events, it is not prejudicial to it. If stronger acids are then poured upon it, the carbonic acid is disengaged and effervescence takes place; therefore, this effervescence, which is regarded by so many persons as a certain sign of the presence of lime or marl, is a very deceptive indication.

We also find iron combined in the soil with sulphuric or phosphoric acid, but not very frequently. When in combination with the former, it produces that substance which is commonly called vitriol (sulphate of iron); land containing this compound is often called vitriolic earth. This matter is only found in those places where there are sulphurous pyrites, the composition of which produces the acid which combines with the iron. It may occasionally be met with in clay situated in damp places, but occurs most frequently in peat marshes, from which vitriol may sometimes be extracted with advantage. Wherever large quantities of vitriol are found, it is prejudicial to vegetation, and destroys the plants; while, on the other hand, when the soil contains only a small portion, and particularly when that is combined with bodies which contain carbon, as with coal or stone, it possesses a fertilizing property: this has been well attested by ancient as well as modern experiments and experience.

Iron is generally found combined with phosphoric acid in that substance which is called *marshy iron.* This body becomes diluted, and often mingles with the superior layer of the soil; where, being exposed to the action of the air, it gradually loses all those properties which are prejudicial to vegetation. Land in which the layer of vegetable earth rests upon marsh iron, is always of the very worst quality, and very sterile.

We must also mention oxide of manganese, which frequently enters, although but in a slight degree, into the composition of the superior layer of the soil, and which is generally found in plants and animals. We have not as yet succeeded in discovering whether or not it has any influence on vegetation.

We have now briefly mentioned the nature of those fixed and incombustible earths, or portions of the soil, which, by means of the proportions in which they are united, constitute all those innumerable varieties of land to which we shall have to recur when we have examined another constituent part of every soil adapted for vegetation, to which it owes its fertility, and which, properly speaking, is neither more nor less than that portion of the food of plants which they derive from the soil: we allude to the *humus.*

## HUMUS.

The name usually given to this substance is "mould." This term has been misinterpreted by many persons, who have understood it to mean the layer of vegetable earth, and not a particular portion of its constituent parts. Several very clever agricultural writers have fallen into the same error; and thus the obscurity which enveloped this part of the science has been increased. It is on this account that I have adopted the word *humus,* about which there can be no mistake. In a scientific point of view the term "earth" is not at all applicable to this substance; properly speaking it is not an earth, and has only been called so on account of the pulverulent form.

Humus is always more or less a constituent part of the soil. The fertility of the land depends entirely upon its presence, for, if we except water, it is to this substance alone in the soil that plants owe their nutriment. It is the residue of animal and vegetable putrefaction, and is a black body; when dry it is pulverulent, and when wet has a soft greasy feel. It is varied in its qualities and composition according to the substances from which it has been formed, and the circumstances under which the putrefaction or decomposition took place; there are, however, certain properties which are inherent to it, and in general it is similar in itself. It is the produce of organic power—a compound of carbon, hydrogen, nitrogen, and oxygen, such as cannot be chemically composed; for in inert bodies these substances only enter into simple combinations of some two amongst them, and do not unite altogether as is the case here. Besides the four essential elements of humus, it contains other substances in smaller quantities, viz., phosphoric and sulphuric acids combined with some base; and also earths, and sometimes different salts.

Humus is the product of living matter, and the source of it. It affords food to organization; without it nothing material could have life, at least the most perfect animals and plants could not exist; and, therefore, death and destruction are necessary and accessory to the reproduction of animal and vegetable life. The greater the number of living creatures, the more humus is produced, and, consequently, the supply of the elements for the nutrition of life is increased. Every organic being in life appropriates to itself a daily increasing amount of the raw materials of nature; and these, after having been digested, resolve into humus, which increases in proportion as men, animals, and vegetables are multiplied in any spot on the surface of the earth. It is, however, diminished by the processes of vegetation, wasted by being carried into the ocean by water, and by being conveyed into the atmosphere by the agency of the oxygen contained in the air, which unites with and gradually converts it into a gaseous matter.

We have only to observe the progress of vegetation upon naked rocks in order to understand the history of humus from the very beginning of the world. At first, only lichens and mosses are found there, from the decomposition of which more perfect plants derive their nourishment; these, in their turn, die and augment the mass of mould by their putrefaction: and thus at last a bed of humus is formed, capable of affording nourishment to the largest trees.*

Voigt, in his supplement to the researches of Saussure, justly observes, " that vegetable mould is vegetable matters partly decomposed, but not completely disorganized. It is a vast pervading plant without organization, which itself bears and nourishes other plants, as a tree affords nutrition to all its branches and shoots. This vegetable mould is composed of vegetable bodies, and it may again be transformed into others of the same or of a similar nature; it is frequently prepared very carefully with a view to this end."

Humus bears some analogy to the bodies from which it is produced, as well as to their constituent parts; but the elementary substances enter into a fresh combination, and some portion is evaporated. According to Saussure, humus contains less oxygen but more carbon and nitrogen than the vegetables from which it is derived. But the circumstances under which it is formed will, doubtless, have no slight influence upon the proportions of its elements and the various combinations which take place between the elementary parts. Thus, for example, humus formed in the open air will not be exactly similar to that which has been formed in a confined place where the atmosphere could not come in contact with it; neither is it the same when placed where it can imbibe a great deal of moisture, as it would have been if kept in a drier place. All these are self-evident facts, although as yet neither the circumstances which influence the formation of humus, nor the deviations attendant on them, have been sufficiently analyzed.

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* Humus is the modern term given by some chemists to the very finely divided organic matters which all cultivated soils contain. " Woody fibre in a state of decay (observes Liebig) is the substance called *humus*. The humic acid of chemists is a product of the decomposition of humus by alkalies; it does not exist in the humus of vegetable physiologists. Humus does not nourish plants by being taken up, and assimilated in its unaltered state; but by presenting a slow and lasting source of carbonic acid, which is absorbed by the roots, and is the principal nutriment of young plants at a time when, being destitute of leaves, they are unable to extract food from the atmosphere."—*Org. Chem.* p. 46.

Even when the humus is formed it is not beyond the reach of alteration and destruction, as it is in constant action and reaction with atmospheric air. When placed under a receiver closed with mercury, it forcibly attracts the oxygen gas, communicates carbon to it, and changes it into carbonic acid gas. If the receiver is closed with water, it creates a vacuum, into which the water penetrates by absorbing the carbonic acid gas, and an almost imperceptible consumption of the humus is thus effected. It is probably by thus producing carbonic acid gas that the humus acts upon vegetation either directly or through the medium of the soil, especially when the stalks and herbage of the plants cover the ground so closely as to prevent too sudden an evaporation of the column of air evolved by carbonic acid gas. De Saussure found that plants filled with succulency, and half dry, recovered themselves much sooner when placed in a bed of humus, or in a soil abundantly provided with that substance, than when deposited in a poor, damp soil. From the experiments made with the receiver, some idea may be formed of the enormous quantity of carbonic acid gas which an acre of land, rich in humus, may be expected to disengage.

Humus likewise experiences another alteration, which De Saussure has also taught us to appreciate in a more particular manner. It forms a certain matter which is soluble in water, and is termed *extractive matter*. This substance may be separated from it by boiling humus which has been exposed to the air several times in water;

when this decoction is evaporated, there remains a residue of a blackish, brown hue. When, after repeated boilings, the humus appears to be entirely deprived of this soluble substance, it will, if exposed for a time to the influence of the atmosphere, again yield extractive matter; but if, on the contrary, it is carefully preserved in closely stopped vessels, none of it can be obtained. According to Saussure, humus which has thus been deprived of its soluble extractive matter, is less fertile, and contains proportionably less carbon than that which has not been boiled. This author states that he witnessed the passage of extractive matter diluted with water immediately into the roots of plants; whence he infers that, next to carbonic acid, this matter is best calculated to afford nutrition, and particularly carbon, to the suckers of plants. The matter of which we are speaking alters when exposed to the air; its solution becomes covered by a thick film or scum, which, when the vessel is shaken, precipitates itself in flakes, and is speedily replaced by a second. This precipitate is insoluble in water, but when united to an alkali it is easily dissolved. A considerable portion of the humus which is met with in nature appears to consist of the substance which has thus been separated and become insoluble.

Fixed alkalies almost entirely dissolve not only humus, but also that part of the extractive matter which has thus become insoluble; during their action, ammonia is disengaged. This solution is decomposed by acids which precipitate an inflammable powder, the quantity of which is, however, very small in proportion to that of the humus. Alcohol does not dissolve humus, it only effects the separation of a small portion of extractive matter and resin.

Humus is not susceptible of putrefaction properly so called, it seems rather to be in opposition to it; for the extractive matter readily enters into a putrid fermentation when separate from it, while so long as it remains in combination with the other portions of the humus this effect never takes place. The vegetation of plants, however, and the formation both of extractive matter and of carbonic acid which takes place when the humus is exposed to the air, at length entirely consume that substance if it is not renewed and replaced by the addition of fresh manure. Were not this the case, much greater quantities of this substance would be found upon the surface of the soil than actually exists there. "The destructibility of this vegetable earth," says De Saussure, sen., "is an undeniable fact; and those agriculturists who have endeavoured to avoid the necessity of manuring their land by bestowing repeated ploughings upon it, have been convinced of this fact by painful experience. They have seen the soil become gradually more and more exhausted, and their fields rendered sterile and barren by the absence of vegetable mould." Probably he here alludes to the experiments made by his countryman Chateauvieux, near Geneva, on the practice of sowing in rows or lines without manuring, which is recommended by Tull, and described at very great length by Duhamel in his treatise on the cultivation of land. In order to prevent the exhaustion of the humus, it is only necessary to restore to the soil, by manuring, some portion of the elements which have been taken from it by the vegetation; because this latter produces so much more than it absorbs, that if all which grows on the land were decomposed by putrefaction, the accumulation of humus would be immense, as is the case in ancient forests and uninhabited plains, the situations of which are favourable to vegetation.

Humus produces different effects, according to the kind of soil with which it is incorporated. Clay, by means of its tenacity, retains the particles of humus which are mixed and incorporated with it, and protects them against the influence of the atmosphere, and consequently prevents them from being so speedily decomposed. It is on this account that clay must be impregnated with a great deal of humus before it will evince any great degree of fertility, because the roots of the plants cannot penetrate so easily into this kind of soil. When such land is cultivated for the first time, and is not endowed by nature with any great depth of humus, it requires repeated and plentiful manurings; but where it is impregnated plentifully with that substance it will retain its fertility for a considerable period without requiring fresh manure. Clay appears to enter into so close a chemical combination with humus, that the latter in some degree loses its properties, and especially its black hue. We have analyzed some clays which were nearly or quite white, and in which we could not perceive any traces of the presence of humus; when submitted to a tolerable degree of heat, they became black, and various appearances attending them served to prove that they contained hydrogenated carbon; when exposed to a still greater degree of heat, the black hue disappeared, and the clay lost a considerable portion of its weight. It frequently happens that land which is irrigated by the influx of neighbouring rivers or seas appears to be perfectly white, although its great fertility might lead us to infer the presence of a considerable proportion of humus, or at any rate of those substances of which humus is composed. In land thus watered, the humus is almost invariably found intimately combined with the clay; this mixture is effected by the water, which washes up the humus and deposits it in the form of mud.

Sand exercises a purely mechanical action on humus; the absence of cohesion between its parts by which it is distinguished facilitates the free admission of atmospheric air to every portion of the humus, favours the separation of carbon under the form of carbonic acid, and also the separation of the extractive matter, and decomposes the humus much sooner. When humus is properly mixed with sand, without any want of humidity, the land thus composed is exceedingly fertile; but this fertility is exhausted more speedily because the humus is more promptly absorbed. In the marshes of Odor there are places where, ten or twelve years ago, a very thick layer of humus covered the sand which had been washed up by the action of the water; this has been exhausted and evaporated so completely, that now nothing is to be seen but loose sand. In the spring, however, even these sterile places are covered with beautiful green turf, which is very remarkable, and can only be explained by considering the quantity of carbonic acid gas which is evolved in these places. Land which contains an excess of humus is benefited by being submitted to a long course of cultivation. If sand is mixed with the spongy and pulverulent humus which accumulates, without the addition of elementary earth, such an admixture tends greatly to ameliorate it; the sand imparts a degree of consolidation to the humus, and renders it less spongy: it does not then absorb so great a quantity of moisture, and gives more consistency and solidity to the roots of the plants which vegetate in it. This has been proved by the results of those experiments in which sand has been used to improve the land, and where the benefit derived from this practice has been even greater than that which might have been expected from manuring. Sand, likewise, is capable of decomposing acid humus and peat, or rather it aids in depriving these substances of their superabundant moisture, and they are then decomposed by the action of the atmosphere.

Humus which has been for a considerable time withdrawn from the influence of the air, is capable of producing very different effects from those produced by that which is exposed to the atmosphere; and this is the case whether the former state results from the hidden portion of humus having formed the lower part of a very thick bed of that substance, or from its having been covered with water or earth. This point has not, as yet, been sufficiently inquired into; we are only able to conjecture what may be the nature of the changes which the humus undergoes when thus withdrawn for a considerable time from the influences of the atmosphere; but that it does possess peculiar properties there cannot be a doubt, although it contains no acid.

It is probable that the carbonic acid and extractive matter cannot be formed or exist without the concurrence of atmospheric air. Most likely a portion of the hydrogen and oxygen is transformed into water, while another portion of the hydrogen dissolves some carbon and evaporates in the form of hydrogenated carbonic acid gas. There is no doubt that while the humus is buried in the earth, less of the carbon than of any of the other elements is taken from it; whereas, when this substance is exposed to the air, an exactly opposite effect takes place.

The longer the humus remains covered, the more does it abound in carbon. It undergoes a species of gradual carbonization. The lowest strata which were formed prior to those which are nearer the surface, have a more carbonous appearance; they are blacker, more compact, and when burnt yield more coal than those nearer to the surface. But if the carbon is only soluble when in combination with hydrogen, it follows, of course, that this humus must be more difficult of decomposition, and will consequently be inert, or, at any rate, less efficacious than the other, until a longer contact with the air has again changed its nature. In fact, experience teaches us that when mixed with recently made manure which emits a considerable quantity of ammonia, this humus becomes much more speedily efficacious; in fact, its effects on the soil are frequently not at all perceptible until the land has been ameliorated with dung.

But its decomposition may also be effected and accelerated by the action of lime; and as a layer of earthy lime produced by shells is frequently found under this substance, the combination may sometimes be very easily effected. Almost the same may be observed with regard to humus or mould which has been under water. If the water only superficially covered it, so that it occasionally became dry, and, consequently, was brought into contact with the air, the effect is the more speedily produced.

When humus remains constantly damp, without, however, being covered with water, it forms a very unpleasant-smelling acid, which is more particularly characterized by the property which it possesses of colouring blue litmus paper into red. This circumstance has long been known, and it is the reason that land and meadows which are not properly drained, and which exhibit these phenomena, are called "*sour.*" We have carefully examined these facts, and have endeavoured to discover the peculiar construction of this acid. At first we were inclined to regard it as being of a distinct nature, and having carbon for its base; but we have since become convinced that it is generally composed of acetic acid, and occasionally contains a portion of the phosphoric. This latter always adheres so firmly to the humus that it cannot be separated from it either by boiling or washing. The liquid in which the humus is boiled certainly acquires a slight acid flavour, but the greater part of the acid remains attached to the humus. All that the water is able to dissolve is a small quantity of brown matter, which, when dry, is very brittle, differs materially from the ordinary extractive matter of humus, and does not possess the power of precipitating itself from its solution when exposed to the air. This sour or acid humus contains a great quantity of insoluble extractive matter, which frequently constitutes the chief part of its weight. When steeped in an alkaline lye, this latter becomes of a dark brown hue, and is thickened by the dissolution of several substances. If this mixture is diluted with an alkali, the extractive matter is precipitated in brown flakes; and what is very remarkable, if more acid is added than is absolutely necessary to neutralize the alkali, it again absorbs the acetic and phosphoric acids, and resumes its former state. But if only so much acid is allowed as will suffice to saturate the alkali, the former remains combined with the latter in the solution, and the extractive matter loses every particle of acid.

This acid, or sour humus, is not at all of a fertilizing nature; on the contrary, it is prejudicial to vegetation. Where it is very strong and pervades the whole of the humus, the soil only produces reeds, rushes, sedge, and other useless unpalatable plants; wherever these abound, it may be inferred that the soil contains a great deal of sour or acid humus.

When land has been drained and deprived of that excess of humidity which is so favourable to the formation of acids, there are various means of getting rid of this baneful property and of rendering the humus fertile. When this has been done, such places will be found to contain rich stores of nutritious vegetable substances concealed there by nature, and which may be either used on the spot or carted and carried to the fields as a manure. It is well known that with the aid of alkalies, ashes, lime, and marl, humus may be deprived of its acidity and rendered easily soluble; should these substances not be within reach, a very efficacious remedy will be found in the humus itself; it is only necessary to burn it, and thus derive the exquisite lime and alkali from the humus itself. Besides, the fire has the property of destroying the greater part of the acidity. This is one reason why paring and burning is generally so beneficial to soils of this nature.

This acid humus is produced by those vegetables which contain a considerable portion of tannin, or, at any rate, something similar to it, and especially by heaths or furzes, even when they vegetate on a dry situation. In places where this family of plants abounds, a soil is frequently found, the deep black colour of which is essentially owing to the humus; although, to all appearance, iron also has a considerable share in producing it. This kind of humus is absolutely insoluble, and only favours the vegetation of those plants whence it proceeds, and they do not thrive anywhere else; heaths, &c., do not thrive in places where this humus does not exist, and when they have once established themselves in one particular spot, they suffer few other plants to appear. This humus may be changed by a dressing composed of marl, lime, or ammonia; and where this has been mixed with the soil, the heaths, &c., speedily perish. Paring and burning is also productive of some good; but it is difficult to keep up a sufficient fire to produce the requisite degree of combustion.

The leaf of some trees, and particularly that of the oak, will likewise produce humus of this nature, if, before its putrefaction, it is not decomposed by very hot animal manure, or by lime and alkalies. Nevertheless, when this substance is exposed to the air, it gradually loses all its baneful properties, and is at length transformed into good humus; but a considerable time must elapse before this effect is produced.

It also appears that in recently formed humus there is a considerable difference between that which is the residue of complete putrefaction, and another portion, the elements of which have only been partially decomposed. This difference has not as yet been sufficiently examined. The former, however, evidently appears to contain a smaller portion of coal; when fire is applied to it, smoke only is given out: while the latter is blacker, possesses more coal, and, consequently, burns more briskly and disengages a larger portion of caloric. In ancient marshes which have been drained or otherwise become dry, a kind of humus is often found which greatly resembles rotten wood, and which, to the depth of a foot and a-half or two feet, forms the principal constituent part of the soil. Land of this nature, although rich in nutritive juices, is not favourable to agriculture or to the growth of cereal plants. I am not yet quite sure whether this arises solely from the soil not possessing sufficient consistency, or whether it is attributable to some peculiar quality possessed by this kind of humus.

Lastly, all humus, and especially that which has been recently formed, possesses essentially different qualities when resulting from the decomposition of vegetable bodies from those which distinguish it when formed by animal decomposition. In the latter case, it contains more nitrogen, sulphur, and phosphorus; the presence of which bodies is rendered quite evident by the odour which it emits when burnt, which is similar to that which arises from the burning of animal bodies.

## PEAT.

Peat is also a species of humus. There have been various opinions relative to the origin and nature of this substance. Formerly, a mineral, or at any rate a semi-mineral, origin was attributed to it; and it was believed to be a mass united and mingled together by bituminous particles: but this opinion is now altogether exploded. It is true that some kinds of peat are met with, which are strongly impregnated with bitumen, but there are others which do not contain any portion of this substance; and even if it were present, it is now well known that bitumen derives its origin from the mineral kingdom. Peat is neither more nor less than the remains of plants in a state of greater or less decomposition. It is found in low, moist situations, where mosses, lichens, and other plants grow, which are with difficulty decomposed; these become interwoven and unite with the mud and various substances deposited by the water; the whole amalgamates, the vegetables putrefy and gradually lose their organic texture, and are at length united with the other substances in a compact spongy mass. When the putrefaction is so far advanced that the organic tissue is totally destroyed, the peat is neither more nor less than a kind of humus; that is to say, a sour humus; but while it contains some degree of consistency, and is not too much mixed with earth, it may be used for the purpose of burning. The plants of which turf is formed, and by means of which it increases in thickness, are those only which grow in moist or wet places, viz., sedge *(carex)*, cotton-grass *(eriophorum)*, marsh ledum *(ledum palestre)*, &c. Van Marum, a Dutch naturalist, regards the *conserva*, or hair-weed, as one of the principal elements of peat; and is so much convinced of this fact as to assert that any soil may be rendered peaty by merely naturalizing this plant on it in some moist situation.*

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* The formation of bog-moss is first commenced in very many instances by the rapid-growing broad-leaved bog-moss (*Sphagnum latifolium*), a plant of very curious habits, whose growth under favourable circumstances (and it is

The circumstances under which peat is formed are subject to considerable variation: the position of the soil with respect to the surrounding country, and especially with relation to the neighbouring lakes and rivers; the degree of humidity which these latter engender; the nature of the plants which constitute the elements of the peat; and, lastly, the substratum of the soil—all these things may differ in different places; and hence, without doubt, arise all those varieties which we find existing in peat.

In a situation where everything tends to accelerate the progress of decomposition, the peat is found existing in a homogeneous heavy black mass; while in others, where decomposition takes place more slowly, it is met with in light fungous pieces, in which are portions of semi-decomposed filaments of plants and vegetables; and, again, in other places it is found entirely composed of bitumen. Peat also presents several other irregularities and varia-

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**strictly an aquatic) extends from an inch in length to two or three feet. In dry situations, or in those only periodically flooded, its progress is not rapid; but when it vegetates, always immersed in the water of low stagnant situations, there it increases with great vigour. It is true that this plant is an annual; but it sheds an abundance of hardy seeds, producing seedlings, which vegetate and easily support themselves in the water, with a slight assistance from the mere remains of their preceding generation. Their thread-like stems remain on the surface of the water till the seed is ripened; they then fall to the bottom and form distinct layers, which, in some specimens of peat, may be distinctly traced. The bog-moss thus commenced gradually gets mixed with a variety of lichens, mosses, and scirpi, which annually add to the depth of the accumulating peat; and as the moss becomes firmer, other plants gradually establish themselves, such as several varieties of the rushes and sedges. It is only when the peat-moss is raised by the gradually-accumulated remains of these peats from beneath the surface of the stagnant waters that the heaths, the cranberry, the bilberry, and the grass-weeds make their appearance. The few plants which commonly tenant peat moors and bogs are of the most worthless kind, such as all live stock commonly refuse. Besides the common heath plants, there are various rushes (*Juncus*), sedges (*Carex*), rush-grasses (*Schœnus*), club-rushes (*Cyperus*), cat's-tail-rushes (*Typha*), bur-weeds (*Sparganium*), &c.**

**Amongst the few specimens of the common grasses which are found in such places, struggling as it were for existence, are the marsh-bent (*Agrostis palustris*), the awnless brown-bent (*Agrostis canina*)—this is a very common grass in bogs whose winter waters are deep—the awned creeping-bent (*Agrostis stolaris*), the small-leaved creeping-bent (*Agrostis stolaris Ang.*), the creeping-rooted bent (*Agrostis repens*), the white bent (*Agrostis alba*), the flote fescue (*Glyceria fluitans*), tall fescue (*Festuca elatior*), turfy hair-grass (*Aira cæspitosa*), knee-jointed fox-tail grass, water hair-grass (*Aira aquatica*), water meadow-grass (*Poa aquatica*), long-leaved cotton-grass (*Eriophorum polystachion*), and the sheathed cotton-grass (*Eriophorum vaginatum*).**

tions, which are more or less evident, and some of which can only be discovered by the most minute examination. It will often be found to be quite different in the same place, being soft and filamentous at the top, and becoming compact, solid and black as we penetrate further into it. This may easily be explained: the peat has not been formed all at once, but gradually, and in successive layers; when one generation of plants perished, another sprang up from its ashes, and thus the mass has been gradually increased. The substrata are, therefore, more ancient than the superior ones; the decomposition is further advanced in the former than in the latter, and in proportion as this is the case, or the higher the state of carbonization in which the plants are found, the inferior layers will necessarily be more putrefied, black, and carbonous.

The greater the degree of decomposition of the vegetable fibres, the more nearly does peat assimilate to humus. The only difference which exists between it and the humus which is found in fields, forests, and uncultivated places, is in the cause to which it owes its existence. Besides, humus, which is formed by the decomposition of, or putrefaction of, vegetable bodies, is not exposed to so continuous a state of humidity as peat; the earth of the soil with which it is mixed acts upon it, while that substance does not exist at all in peat, properly so called. In the greater number of cases, peat is very much like acid or sour humus; indeed, it sometimes resembles it so strikingly that it is impossible to distinguish these substances apart. Peat, like sour humus, contains acetic and phosphoric acid and ammonia; and even when it does not contain acid, it possesses a great quantity of insoluble extractive matter, which can only be rendered soluble by an admixture of potassa and acids. Pyrites have occasionally been found in peat; these substances have, doubtless, been introduced externally, but by what means is as yet unknown. During combustion it emits a sulphurous odour, and likewise sometimes produces upon its surface a salt which smells like ink, and is no other than sulphate of iron or vitriol.

The constituent parts of turf, like those of humus, are carbon, hydrogen, nitrogen, and oxygen. All peats do not contain an equal quantity of carbon. The older the peat is, the more of this substance does it possess; and as, when used for burning, its quality depends upon the quantity of carbon contained in it, it follows that the older it is the better is it adapted for that purpose. When exposed in a dry place and mixed with potassa or lime, it becomes decomposed, is freed from its acidity, and transformed into a mild fertilizing humus.

Another combustible substance which is sometimes found at a small depth below the surface of the soil, and occasionally beneath peaty marshes, is *coal* or *bituminous wood*. Coal not only serves as a combustible and is useful to the agriculturist in enabling him to calcine lime, but it also appears to yield a species of manure which is most active when mixed with sulphurous pyrites and iron, because the decomposition of the former creates vitriol, which, when a small portion of it in this combination is spread over the land, appears to have a favourable effect upon vegetation.

## THE DIFFERENT SPECIES OF EARTHS, THEIR VALUE, EMPLOYMENT, AND PROPERTIES, IN THEIR RELATIONS TO THE CONSTITUENT PARTS OF THE SOIL.

Each of those substances of which we have been speaking would, if alone and isolated, constitute a sterile soil, or, at any rate, one totally unfit for the purposes of agriculture. The quality of a soil results almost entirely from the proportions in which these earths are united in it, and the infinite variety of these proportions gives rise to the innumerable kinds of soils which are met with in nature, and which are not separated from one another by any limits or line of demarcation, but merely by almost imperceptible shades of difference.*

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* To a certain extent, it may be taken to be the fact, that the richer soils have the least specific gravity. In the experiments of the Rev. W. Rham, a good garden mould, consisting of—

Hitherto, the various kinds of land have been classed in a practical manner, according to the degree of fertility observed in them, and the species and value of the products which could be obtained from them. But this mode of classification has been considered defective; and such it necessarily must be, so long as it continues to be

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| | |
|---|---|
| Clay | 52·4 |
| Silicious sand | 36·5 |
| Calcareous sand | 1·8 |
| Carbonate of lime | 2·0 |
| Organic matter | 7·3 |

had a specific gravity of 2·332.

A good loam, consisting of—

| | |
|---|---|
| Clay | 51·2 |
| Silicious sand | 42·7 |
| Calcareous sand | 0·4 |
| Carbonate of lime | 2·3 |
| Organic matter | 3·4 |

had a specific gravity of 2.401.

A poorer soil, of which the component parts were—

| | |
|---|---|
| Silicious sand | 64·0 |
| Clay | 32·3 |
| Calcareous sand | 1·2 |
| Carbonate of lime | 1·2 |
| Organic matter | 1·8 |

had a specific gravity of 2·526.

To those who may be inclined to try the analysis of soils, it may be interesting to compare the results of their own experiments with some which have been obtained with great care. Thaer has, in another place, given a table in which different soils analyzed by him are classed according to their comparative fertility, which is expressed in numbers, 100 being the most fertile. This table is the result of very patient investigation, the natural fertility of each soil being ascertained by its average produce with common tillage and manuring. It is as follows:—

| Clay. | Sand. | Carb. of Lime. | Finely divided Organic Matter or Humus. | Comparative Value. | |
|---|---|---|---|---|---|
| 74 | 10 | 4 | 11½ | 100 | Rich alluvial soils. |
| 81 | 6 | 4 | 8½ | 98 | |
| 79 | 10 | 4 | 6½ | 96 | |
| 40 | 22 | 36 | 4 | 90 | |
| 20 | 67 | 3 | 10 | 78 | Good wheat and barley lands. |
| 58 | 36 | 2 | 4 | 77 | |
| 56 | 30 | 12 | 2 | 75 | |
| 60 | 38 | Very little carbonate of lime. | 2 | 70 | |
| 48 | 50 | | 2 | 65 | |
| 68 | 30 | | 2 | 60 | Barley land, not fit for wheat. |
| 38 | 60 | | 2 | 60 | |
| 33 | 65 | | 2 | 60 | |
| 28 | 70 | | 2 | 40 | Poor sand, fit only for oats or buckwheat |
| 23½ | 75 | | 1½ | 30 | |
| 18½ | 80 | | 1½ | 20 | |

founded on any other basis than a sound knowledge of the constituent parts of the soil. Where attempts have been made to class different kinds of land according to their constituent parts, sufficient attention has not been paid to their fertility and to the effects produced when they are cultivated; but no decisive experiments appear to have been made on this subject. We have chemically analyzed several kinds of soils, and at the same time have endeavoured to obtain some more accurate knowledge of the effects produced by each of them upon agriculture and vegetation generally. The results of our attempts have certainly enabled us to throw more light upon the subject than other authors have done, but there still remains a wide field for inquiry and research. Thus, then, although the following remarks must be merely regarded as a primary and consequently imperfect attempt to distinguish and class the different kinds of soils, yet I cannot but regard them as useful, if they merely serve as lights to warn us of errors, and point out the path which will lead to a clearer and more thorough knowledge of the subject.

In the ensuing estimation of soils, valued according to their constituent parts, I shall suppose them all to be equal in every other respect, viz., with regard to position, depth, humidity, &c. &c.; and shall afterwards consider the influence of all these circumstances separately.

The humus is, as we have already observed, that portion of the soil from which plants derive their nutriment. The richness of a soil, or that quality which it possesses when it is said to be fat, depends essentially upon the proportions of humus which it contains, although many persons understand the term " fat," to apply to land of a more or less argillaceous nature. Humus also exercises a physical action upon the soil; it renders argillaceous land or stiff clay more porous, facilitates the action of the atmosphere upon it, and tends to loosen and pulverize it; it gives consistence to, or consolidates, sandy soils, and when mixed with them enables them to retain moisture. This substance has likewise a very beneficial effect upon land which contains too great a proportion of lime, rendering it milder, less irritating, more consistent, and preventing moisture from evaporating from it too easily.

This fertilizing matter may, however, exist in too large a quantity. Where this is the case, the soil is too friable and spongy, and is not sufficiently consolidated to enable it to yield a firm support to the roots of the plants which vegetate in it; it absorbs water like a sponge, and, when the weather is damp, becomes so saturated with moisture that it almost resembles a marsh; consequently, those plants which are sown in it are subject to all the evils entailed on them by superabundance of humidity, and either become diseased or perish. In dry weather, on the contrary, such a soil allows the moisture to be too easily evaporated, and then its surface becomes so dry and pulverulent that the seeds sown in it cannot germinate, or, what is worse, they dry up and perish after having germinated; while at the depth of some inches, where the atmosphere cannot penetrate, it remains so wet, that if a portion be squeezed in the hand, water will drop from it. Besides this property, a soil which is surcharged with humus will, at each sensible change of the temperature, contract or dilate; thus detaching the roots of the plants from their hold, and frequently throwing them up so much that nothing but the mere extremity remains attached to the soil. Land of this nature is less adapted for autumnal than it is for spring corn, and oats answer better on it than barley, because they are stronger and more tenacious. Lastly, it favours the growth of all kinds of weeds which vegetate in it so rapidly that they totally choke the cereal plants.

A soil which contains too great a proportion of humus, however good and mild that substance may be, can only be rendered profitable by being used to improve and ameliorate poorer lands.

If it is tolerably humid, it will often be profitable to transform it into meadow land, and then, if not inclined to be marshy, it will soon yield very rich pasturage, especially if sown with proper gramineous plants, as the *alopecurus pratensis* (meadow fox-tail grass) and the larger varieties of the *poa* and *festuca*. If dry, it may be ameliorated by means of additions of poorer soils, or, what is still more easy, by incineration, or paring and burning, which consumes and transforms a portion of the excess of humus contained in it into ashes; but after this operation has been performed, care must be taken that the corn does not fall or become lodged so early as to be spoiled.

Clayey or argillaceous land can bear a greater proportion of humus without injury than any other kind, because the properties of the clay correct those of the humus. I shall not venture to decide what is the precise degree to which the addition of humus increases the value of clay soils. The richest land I ever analyzed, and which was taken from the marshes of the Oder, contained 19¾ parts in a hundred of humus, 70 of clay, a little fine sand, and an almost imperceptible quantity of lime; but the situation of this land was too low, and it was too damp to admit of a correct estimate being formed of its fertility. Autumnal corn could not be raised there at all, on account of these circumstances; and the success of the spring crops was always uncertain. Upon the whole it was tolerably consistent, and possessed a sufficient degree of cohesive attraction for water. I have never found more than 11½ parts in a hundred of humus in any other clayey soil; not even in what is called "fat land." But I have never yet had an opportunity of examining or analyzing any of those inexhaustible soils which are capable of bringing the crops to full maturity every year without being manured, and in which no diminution of fertility is observable so long as the requisite degree of cultivation is bestowed on them; nor of analyzing those soils which are said to be deteriorated rather than improved by manure.

It is asserted that such land is to be found in the Ukraine, in Hungary, and in several other places, and that some few circumscribed portions of it are to be found even in Germany. Several soils which we have analyzed, were once considered to be inexhaustible: but when they came to be broken up for the first time and brought into cultivation, it was generally found that, after bearing a series of crops, most of which were suffered to arrive at maturity, they required manuring, if not laid down for grass or meadow land, in order to give them time to recruit their exhausted energies and regain their succulency, or ploughed or dug up with the spade sufficiently deep to bring to the surface the under layers which had not been touched. There are now very few countries in which it is thought possible to go on entirely without manure, and in these the land is usually devoted more to grass and to the feeding of cattle than to the cultivation of corn. The richest argillaceous soil that I ever analyzed, the fertility of which was regarded as of the very richest quality, was taken from the right bank of the Elbe, some few miles from its mouth; it contained eleven and a-half parts in a hundred of humus, four and a-half of lime, a great quantity of clay, a little coarse silica, and a considerable portion of very fine silica, which could only be separated from it by ebullition. It certainly possessed a great degree of cohesion, but when moderately moistened it was not very tenacious. It was made to bear the richest crops, as cabbages, wheat, autumnal corn, beans, &c., but every sixth year it was necessary to manure it thoroughly and to give it a fallow.

We have found humus mixed in various proportions with clay in those low lands, which, when submitted to a judicious rotation, are so very fertile. A portion of land in Budjading, the whole of which country is regarded as particularly fertile, contained $8\frac{3}{5}$ parts in a hundred of humus, three or four of lime, and the rest was almost pure clay. The land of the bailiwick of Wallup, which contains $6\frac{1}{2}$ parts in a hundred of humus, is also excellent land for wheat, since it will produce three crops of that kind of grain after having been manured, and all equally fine, strong, and plentiful.

We must not always suppose that because the soil is of a dark colour it contains a large proportion of humus;

sometimes land of a whitish hue contains considerably more humus than that which is brown, or nearly black; but, if a light-coloured soil be submitted to incandescence in a closely stopped crucible, the dark hue will speedily develop itself if the soil contains humus.

These rich argillaceous lands are only met with in low situations, valleys, near the beds of rivers, or other places, where the inundations of water have deposited a layer of mud of greater or less thickness; as, for example, in valleys which once constituted lakes before the waters dried up or were turned off in some other direction, or on the margins of rivers whence the water has gradually retired as the course of the stream became altered. Land of this nature is generally entered in the first class, under the denomination of *rich wheat land*, because, in the triennial rotation with a fallow, it can bear three crops of wheat without requiring fresh manure.

Soils comprised in this class have different degrees of fertility and value. I shall not permit myself to determine whether or not they ought to be estimated solely with relation to the proportion of humus which they contain: comparisons with respect to fertility where the lands lie at considerable distances from one another are difficult; and, besides, the fertility depends so much upon climate and temperature. Neither can I positively state whether or not the greater or less proportion of lime and animal matter which are so often mixed with the soil, may not have some influence upon its fertility.

From the results of my inquiries and experiments, I think that I may venture to assert, that a vegetable soil ought to contain at least from five to six parts in a hundred of humus, to entitle it to be comprised in this class. In order to designate the proportions of the value of different soils, we shall fix that of the most fertile at a hundred; but this value will necessarily be increased or diminished by the influence which situation, climate, and other concomitant circumstances exercise on the utility of land.

Land in which humus is combined with a small portion of clay and a large quantity of sand, must not be comprised in this class; the compost which results from this mixture possesses little cohesion, more readily allows the admission of heat and moisture, and at the same time permits them to be carried off with greater facility. Here the proportion of humus may easily become too great. We have analyzed a soil which contained twenty-six parts in a hundred of humus, and the rest equal parts of sand and clay; it was very friable and little adapted for the cultivation of corn. When drained and broken up, the first crops which it bore were very rich, but its fertility rapidly diminished; and, although every attempt was made, by means of abundant manurings and ameliorations, to restore to it that which it had lost, it never regained its original fertility.

On the other hand, another soil which was still more sandy and contained about ten parts in a hundred of humus, appeared to us exceedingly fertile, and well adapted for every kind of cereals excepting wheat, especially after it had been laid down as pasturage for several years. This land, however, required a great deal of manure, and was never so profitable as when manured before the last crop raised upon it previous to its being laid down for grass. Experience proves that land of this nature may easily be exhausted, if not manured and allowed some period of repose. We do not as yet know what proportions of clay it ought to contain in order to ensure the success of repeated crops of wheat. If it contains twenty parts in a hundred of pure clay, ten parts in a hundred of humus, and the rest sand, it produces excellent barley; when it contains less clay, the crops of oats are not so casual, if the climate and temperature be humid; the rye crops too are abundant, provided that the seed is sown sufficiently early to gain strength enough to withstand the winter.

Land should chiefly be valued according to its consistence: the greater the degree of this quality which it possesses, the nearer does it approach in value to that assigned to first class land, viz., 100; but the smaller the proportion of clay and the larger the quantity of sand which enters into its composition, the more rapidly does it fall in value to 80, even when it contains from ten to fifteen parts in a hundred of humus. This kind of land is only found in plains or valleys, or near the beds of rivers, and is seldom deficient in humidity. There the humus has been formed by the decomposition of those aquatic plants which were constantly re-produced for centuries in the water which formerly covered these low lands: when the water subsided or disappeared, the plants entered into a state of putrefaction of greater or less duration: it is the duration and inequality of this putrefaction which causes the humus to appear to contain a greater or less quantity of carbonic acid.

In both the kinds of land which we have been considering, we have supposed the humus to be mild, that is to say, exempt from acidity. Sour or acid humus totally destroys the fertility of a soil; sometimes, however, the soil contains so very small a portion of acidity, that its fertility is very slightly diminished, and only with regard to some few plants. Barley crops become more and more scanty in proportion as the acidity is increased; but oats do not appear to be at all affected by it. Rye grown on such land is peculiarly liable to rust, and is easily laid or lodged: the grains of all the cereals become larger, but contain less farina. Grass which grows on these spots is, both in species and taste, less agreeable, and less suitable for cattle, than any other, although it yields a very considerable produce in hay. In fact, in exact proportion with the increase of acidity, is the decrease in the value of the soil, and this goes on from bad to worse until the soil is no better than what we call marshy land.

A blackish hue on the soil usually induces the supposition that it contains an abundance of humus; and, in the majority of instances, this opinion will prove correct, unless the colour arises from the presence of oxide of iron, or manganese; the remarkable fertility of land coloured by humus does not admit of its being long mistaken.

All doubts upon the subject may, however, soon be removed by submitting a ball of the earth in question to incandescence in an open crucible, which will allow the atmospheric air to come in contact with it; in this case, if the dark colour arises from the presence of humus, it will speedily disappear, and the earth will become quite white, an effect which is not produced when the dark hue arises from oxide of iron. The simplest means of ascertaining and estimating the quantity of humus contained in a soil is to burn it. A certain portion of the soil which we wish to analyze, taken not too near the surface, should be dried in the sun until it pulverizes in the hand and feels quite dry; the small stones should then be picked out, and the remaining portion accurately weighed, placed in a crucible, heated to a perfect state of incandescence, and kept in that state for about ten minutes, or at least until the black hue has entirely disappeared, and gently moved or stirred with a glass tube all the time. In order to accelerate the total combustion of the humus and shorten the operation, a small portion of nitrate of ammonia may be united with the earth, which completely volatilizes that substance. The diminution of weight will indicate the quantity of humus which the soil contained. There is no doubt that the earth, especially if it be of an argillaceous nature, loses some of that water which was so closely united with it, to be evaporated only by the process of incandescence; but this will make a very trifling difference in the weight, and if the earth was previously well dried, it will not amount to a fraction. But where the soil contains a good deal of lime, the volatilization of its carbonic acid as well as of its water of crystalization, will cause a sensible difference in the result of the experiment; it is, therefore, highly necessary to begin by getting rid of the lime. The acidity of humus may be detected by immersing a strip of blue turnsole paper in a liquid paste, formed of the earth we wish to analyze, and water. If the paper turns red, that may be considered as a certain sign of the presence of an acid. Sour or acid humus also betrays itself by the peculiar odour which it emits when burned, an odour similar to that given out by burnt turf. If humus, when burning, smells like burnt feathers, that is a sign that it originates in animal matter, and is, consequently, richer, and may be more easily decomposed.

There is no doubt that a more definite analysis of humus might be effected by means of the pneumatic apparatus, and by dry distillation; but an agriculturist has it not always in his power to perform this operation. Arthur Young frequently performed these experiments, and found that the quantity of hydrogen gas which he obtained was always in exact proportion with the fertility of the soil. The experiments conducted by Priestly were attended with similar results, and serve to confirm this fact.

Clay increases the fertility of the land: 1. By the adhesion which it contracts with water. This adhesion is so great, that, even during a long drought, the clay always preserves that humidity which is indispensable to the nourishment of plants; and, although it may appear to be entirely parched up, it is still capable of communicating to them that moisture without which they could not exist. 2. By the solid support which it affords to the roots of plants, as well as by the resistance which it opposes to their too great extension, obliging them to put forth several tufts of short fibrous roots, by means of which each plant seeks its nourishment in the circumscribed spot; and, consequently, does not deprive its neighbours of their fair share. 3. By preventing the atmospheric air from coming in contact with the roots of the plants, to which it is almost invariably injurious, and by communicating to them a moderate and equable degree of warmth; thus preserving an equality of temperature, notwithstanding the constant changes going on in the atmosphere. When argillaceous land is not too damp, the effects of sudden changes from hot to cold, or *vice versa,* are, consequently, less injurious to the crops growing on it, than they are to those which grow on sandy soils. 4. It attracts oxygen, the substance which is so necessary to the formation of carbonic acid. It probably attracts nitrogen also; and thus favours the reciprocal action of these substances upon each other.

On the other hand, an excess of clay is injurious: 1. Because in damp weather it retains the water with which it is impregnated too long, neither suffering it to drain out or evaporate, but forming with it a tenacious paste. 2. Because in dry weather it becomes too hard, opposes too great a resistance to the roots of the plants, and, not unfrequently, contracts and becomes not unlike a mass of brick. 3. Because, both during the summer heat and the winter frost, it cracks into gaps or clefts, by which means the roots of the plants are torn or brought into immediate contact with the atmospheric air, which is generally injurious to them. 4. Because it forcibly attracts and incorporates with itself all the nutritive juices contained in the manure bestowed upon it, and cannot be made to part with them again so easily as in looser and lighter soils. In fact, when it has once been thoroughly ameliorated, and in a manner saturated with manure and brought into good condition, it retains its fertility for a considerable period: but, if once impoverished or exhausted, the first manurings bestowed upon it have little or no effect upon the vegetation. Land of this nature, therefore, must be manured very plentifully, or the first crops derive little or no benefit from the amelioration. 5. Because it renders the task of cultivating the soil exceedingly difficult. In damp, wet weather it is almost impossible to pass either a plough, harrow, or waggon over it; it sticks to the two former instruments, clogs them, and impedes their action, and can with difficulty be divided; while in dry weather it contracts and becomes so hard that it is with the greatest difficulty a plough can divide it even into large clods, and these, until they have been moistened by rain, can neither be broken by the harrow or the roller, and, not unfrequently, a mallet is obliged to be used for this purpose, and even then the end in view is but very imperfectly attained.

The injurious effects of an excess of clay may, in part, be counteracted by the addition of humus; but, as we have already stated, this will not entirely obviate them. Lime is also rather beneficial in this case, as we shall presently see. But nothing is so really beneficial as sand, and that is the substance which is generally used. The superior layer of the soil always contains some portion of sand; and, were not this the case, it would be scarcely possible for any agricultural implement to act upon it. Consequently, the estimation of most lands ought principally to be based upon the proportions in which clay and sand are united in them.

Previously to pointing out what these proportions are, I must, in the first place, explain precisely what I mean by sand. My intention is to designate, under this term, that coarse-grained silica which, when any portion of earth is carefully washed, is precipitated to the bottom of the vessel, and can there be collected. Recent experiments have shown us that, when clay is boiled in water, a considerable quantity of fine-grained silica is separated from it; and that, if this operation is prolonged and carefully performed, the alumina will at last be deprived of nearly the whole of its silica. It appears that the quantity of this fine silica constitutes the principal difference which exists between rich and poor clay; that clay, properly so called, is always composed of the same proportions, and is not chemically combined, at least in an intimate manner, with a fixed and definite quantity of silica, although it may be mechanically united with a much larger portion. I cannot, as yet, affirm that such is the case, but I think it very probable.

As the end we now have in view is to regulate and determine the value and utility of land, according to the proportions of its constituent parts, and to effect this purpose in the simplest possible manner, we shall not pay any attention to this fine silica which cannot be separated except by boiling; but regard clay as pure when it has been carefully washed. In by far the greater number of cases, at least fifteen parts more of fine silica might be extracted, by boiling, from a hundred parts of clay which has been purified by washing. The proportion of this substance obtained from some particular kinds of land is still greater. The experiments and researches hitherto made do not enable us to determine how far clay which contains a still greater portion of this substance is benefited by the addition of sand, and what quantity of that matter is necessary to give it the requisite degree of porousness.

When the soil is composed of almost equal parts of pure clay and of that kind of sand which can be separated from it by washing, we designate it clay land, or potters' earth; and we preserve this denomination so long as the soil does not contain more than from forty to sixty parts in a hundred of sand; and according as this proportion is increased or diminished in it, we term it *loose* or *stiff* and *tenacious clay land.*

A soil which contains less than forty parts in a hundred of sand, is called argillaceous land; the smaller the proportion of sand which it contains, the more stiff and tenacious does it become, and the more evident are the defects of the clay. Land containing, at most, only twenty parts in a hundred of sand, is very stiff and crude, and cannot be tilled without great difficulty, unless its defects are corrected by a considerable admixture of humus or lime. Its quality, however, depends in a great measure upon the nature of the clay, and the quantity of silica which enters into its composition: such a soil is less defective if, while it contains only a small portion of sand, it possesses a large quantity of silica.

When this argillaceous land does not contain sufficient humus to enable it to bear wheat without being manured afresh, and, consequently, cannot be entered in the first class, it will be termed wheat land of the second quality, or second-rate wheat land; but then it must not be totally destitute of humus. On rising grounds, or eminences, we seldom find land submitted to ordinary cultivation which contains more than three parts in a hundred of this compound matter; nevertheless, such land is well adapted for wheat, and that species of cereals succeeds much better and with less trouble than rye. Next to wheat, barley thrives best there, if the soil contains from thirty to forty parts in a hundred of sand; but when it only contains a smaller proportion, and this defect is not remedied by a strong admixture of lime, it is better adapted for oats. Such land is also exceedingly proper for the growth of vegetables, provided that it is sufficiently ameliorated: that which contains most sand is favourable to peas, while a stiffer and more tenacious soil grows beans with greater advantage.

The value of land diminishes in exact proportion with the decrease in the quantity of the sand contained in it, unless it belongs to the class of marly or calcareous soils, or to those which are strongly impregnated with humus; thus a soil containing forty parts in a hundred of sand is of the greatest value, while that which contains but five parts in a hundred is much less esteemed. A tenacious and argillaceous soil which is plentifully manured, and situated where an alternately hot and moist temperature not only favours the operations of ploughing and fallowing, but also the processes of vegetation, is sometimes very superior, especially for the growth of wheat; but if we come to consider the difficulty there is in cultivating it, and how much more uncertain and casual the crops are there than they would be on a lighter soil, there can no longer be any doubt as to its inferiority in value. I estimate land which contains two parts in a hundred of natural humus, forty of sand, and about sixty of pure clay, at 70; that which only contains thirty parts in a hundred of sand, at 60; that which contains but twenty parts, at 50; and that which contains only ten parts, at 40. Should it not possess more than one part in a hundred of humus, its value is decreased at least twenty per cent. Thus, tenacious soils which contain little or no mild, soluble humus, and which is usually termed cold, damp land, is actually one of the most sterile that possibly can be, and may, in point of value, be assimilated to sandy land. On the other hand, its value is increased in proportion to the quantity of humus and clay which it contains; and such land may even be good enough to be entered in the first class, when it can be abundantly manured and properly tilled.

Land which contains more than forty, or from that to sixty parts in a hundred of sand, is usually designated clay, or potter's earth but the less the proportion of sand falls below forty parts in a hundred, the greater is the value of the land, supposing it to possess an equal quantity of humus. Where the proportion of sand does not exceed fifty parts in a hundred, the soil is equally adapted for the production of wheat and barley. But when that proportion increases from fifty to sixty parts in a hundred, wheat certainly may be grown there, provided the soil is properly cultivated; but the crops are never very fine or very abundant, and the land is much more impoverished than it would have been if cropped with rye: such a soil is, however, peculiarly well adapted for barley, and may be classed among the very best of those lands which are destined to bear this kind of grain.

The inherent advantages of a soil of this nature, viz., of causing the crops to be less casual and uncertain, being more easily worked and tilled, preserving a moderate degree of temperature and humidity, &c., render it so very superior to argillaceous land, that, notwithstanding its being less adapted for wheat, it may be assimilated to whe t land in all its various gradations. In this case, the gradations are in an exactly inverse direction; forty parts in a hundred of sand appearing to us to be the best proportion. In the former case, the value of the soil decreases when the proportion of sand diminishes; in the latter, on the contrary, the value decreases when the proportion is increased, but not in the same ratio. From the observations which we have hitherto been able to make the value of the soil appears to be almost equal in the following opposite proportions :—

| Sand. | Pure Clay. | Sand. | Pure Clay. |
|---|---|---|---|
| 50 parts in 100 | 50 parts in 100 | 35 parts in 100 | 65 parts in 100 |
| 60 „ | 40 „ | 30 „ | 70 „ |

That is to say, the former are defective on account of their want of consistence, and the latter on account of their too great tenacity.

This kind of land may be vigorously tilled without becoming pulverized, neither does it harden into clods and furrows; it is seldom injured by an excess of moisture, and yet preserves sufficient humidity to enable it to resist the effects of drought for a considerable period; and young plants suffer much less in it than in tenacious soils, because their roots are better able to extend in all directions and penetrate it; and this is the reason that barley succeeds and flourishes so much better here. Such land will, doubtless, only bear fine crops of wheat when it has been thoroughly ameliorated; but, even when in a less fertile condition, it produces finer crops of rye than are grown on more argillaceous lands. It is also peculiarly adapted for vegetables, as potatoes and radishes, for clover and other kinds of fodder, and for plants of commerce, as cabbage, linseed, tobacco, &c., the cultivation of which is easy. It seldom offers any opposition to the action of the plough and harrow; and on this account, although it does not yield fine or large crops of wheat even in favourable years, it ought in the gradations pointed out to be assimilated to *wheat land*, properly so called.

Sand is injurious when it enters too largely into the composition of the soil: 1. Because it is not sufficiently retentive of moisture, but allows the water to evaporate or drain away, and carry with it the fertilizing particles and juices. 2. Because it does not combine with the humus, and hardly enters into a physical union with it sufficiently strong to absorb those fertilizing particles which the atmosphere contains. 3. Because sandy soils will not bear frequent cultivation, although constant tillage is necessary in order to destroy the weeds which multiply so rapidly in land of this nature, especially when it contains a fair quantity of humus; and because these repeated workings deprive it of every particle of coherence, and, instead of ameliorating, tends rather to impoverish it by bringing to the surface all that humus which was amassed in the interstices without being combined with the soil, and thus exposing it to the action of the atmosphere and the winds which rapidly decomposes it and carries it away. 4. Because sandy soils being good conductors of caloric, they transmit the influences of severe cold or intense heat immediately to plants at each sudden change which the temperature of the atmosphere undergoes.

A soil which contains more than from sixty to eighty parts in a hundred of sand is termed *sandy clay*. The value of this land diminishes in proportion as the sand increases; if that which contains sixty parts in a hundred is valued at 60, land containing sixty-five parts ought not to be estimated at more than 50, seventy parts decrease the value to 40, seventy-five to 30, and, lastly, that which contains eighty parts to 20. Wheat crops cannot be reckoned upon here with any degree of certainty; and if the land contains seventy parts in a hundred of sand, it is not at all adapted for the production of this kind of grain, unless it be submitted to a peculiarly enriching course of tillage; but it is well calculated for barley, particularly when the situation is favourable and the summers are not too dry. It is easily worked or tilled, but is more liable to be overrun and infested with weeds than argillaceous soils. It has no great degree of cohesive attraction for manure, but, on the contrary, rapidly decomposes that substance, and allows it to pass into the plants which vegetate there. This accounts for its requiring frequent manurings, although these need not be very plentiful. When rich and abundant ameliorations are bestowed upon such land, it will become very rich in humus, and eventually be rendered exceedingly fertile; but this fertility rapidly declines if the soil is submitted to an exhausting rotation.

If it contains seventy-five parts in a hundred or more of sand, it is usually designated *oat land;* nevertheless, if we take the average of several years, we shall see that it is more proper for barley than for oats, provided it be sufficiently manured.

A soil which contains more than eighty parts in a hundred of sand, is called *sandy land*; and if the proportion of this substance does not exceed ninety, it is distinguished by the term clayey sand. Usually, so long as land does not contain more than eighty-five parts in a hundred of sand, it is comprised in the class of oat lands; nevertheless, the success of this grain is by no means certain, and it often yields little or no produce. Rye and buckwheat are the only kinds of grain which it bears with any degree of success; and if it has been sufficiently ameliorated, it is always better to sow successive crops of rye than to sow oats after rye, because the dryness to which this soil is exposed during the summer is less prejudicial to rye than to oats. Of all the plants or vegetables which are grown for the purposes of feeding cattle, potatoes have been cultivated with the greatest success on this sort of land. But the frequent ploughings which, when this land is in good condition, must be bestowed upon it, in order to cleanse it from weeds, are apt to render it so loose and friable that not any of the cereals can be made to succeed on it. This is the reason that it is advisable to allow it a certain period of repose, or to lay it down to perennial pasture; and this latter is the means by which the greatest amount of advantage can be derived from it, for when sown with sheep's fescue-grass *(festuca ovina)*, rye grass *(lolium perenne)*, Dutch clover *(trefolium repens)*, common burnet *(poterium sanguisorba)*, &c., it produces a pasturage which is exceedingly well calculated for sheep, although not usually sufficiently rich for cattle. After this period of pasturage or repose, the land may be cultivated afresh, and will, if sown with rye, yield very fine crops.

The value of it decreases from twenty to ten in the ratio of one for every hundred in which the proportion of sand increases; and this diminution takes place even when the land contains from one to one and a-half parts in a hundred of humus; and if, as sometimes happens, it contains a yet smaller proportion, its value is still less.

But if the land contains ninety parts in a hundred of sand, it then belongs to a still lower class, unless it is abundantly manured; nor until after a long period of repose can it be made to bear a crop of cereals with any degree of advantage, and then this crop impoverishes it very much. Land which does not contain more than ninety-four parts in a hundred of sand may, if properly managed and sown with the small varieties of the *festuca's* and vernal-grass, be made to yield herbage enough to feed one sheep per acre during the period of repose. But when the soil contains a yet larger portion of sand, it will only bear grey-hair-grass *(aira canescens)*, yellow goats'-beard *(tragopogon pratensis)*, and some other plants which contain scarcely any nutritive juices; it then falls into the class of loose blowing sands, the surface of which it is very dangerous to break, because then the wind moves it and carries it away in whirlwinds.

It may be regarded as an invariable rule that sandy soil loses at least one part in a hundred of its value by the augmentation of a hundredth part in the proportion of sand; and when it degenerates into loose blowing sand, it possesses a mere negative value in by far the greater number of cases.

There are many kinds of sand which are not composed solely of silica, but also contain some grains of carbonate of lime. This calcareous sand is not so insoluble as the silicious, and is much more favourable to vegetation. We do not, however, yet know any decisive experiments which bear upon this point.

The presence of lime, especially when it is intimately combined with clay, increases the fertility of the soil to a certain degree. 1. Because, when intimately and uniformly mixed with clay, it renders that substance more friable and less tenacious. Such a mixture is easily reduced to a fine powder by exposure to the air. 2. Because it facilitates the drying and aerefaction of the clay, and prevents too great an accumulation of water from taking place in it. It appears, on the other hand, to consolidate sand, increasing its cohesive attraction for water, and intimately uniting with it by means of the humus. 3. Because it favours the decomposition and reciprocal action of the nutritive juices contained in the soil, and separates those animal or vegetable substances which adhere too closely to the clay. It is as yet doubtful whether it transmits its carbonic acid to the humus or even to the plants themselves; whether, on the other hand, it absorbs it from the air, and consequently acts as a nutritive body. There are, however, various reasons to induce us to believe that such is the case. 4. Because it prevents the formation of those acids which are so easily produced in the soil; or where they already exist, it tends to neutralize them and prevent them from being injurious. 5. Because the husk of grain grown on land which contains a suitable portion of lime is much thinner, and the grain itself yields a considerably larger quantity of farina; and further, because it is singularly favourable to all plants belonging to the class "diadelphia," and, consequently, to those which bear pods; all kinds of clover succeed wonderfully on it.

When a soil contains too great a proportion of lime, that substance is apt to become prejudicial. This is especially the case in districts where a chalky formation exists. 1. Because it does not retain moisture, and has even a greater disposition than sand to suffer it to evaporate; consequently, during warm, dry weather, it is totally parched and reduced to dust. 2. Because it consumes manure and humus very rapidly, accelerates the passage of these substances to the plants, and thus hastens their vegetation at first; and does not reserve any nutrition for their support during the latter stages of their development; on which account they fall off and perish before they arrive at maturity.

As I know not any kind of soil which contains a superabundance of lime, I shall quote a passage from one of Chaptal's works:—"Land, in which there is a preponderance of lime (M. Chaptal means carbonate of lime) is porous, light, easily permeable by water, can be tilled without difficulty, forms a paste which possesses little or no consistence, and is not sensibly altered by the action of fire. The air easily penetrates calcareous earth, and is there capable of vivifying the germs which it contains to a certain depth; but water, which penetrates it without resistance, escapes again with equal facility. Land of this nature is alternately swamped and parched; and those plants which are not strong enough to withstand such variations, languish or perish in a soil of this nature."

According to Reissert and Seitz ("Annals of Agriculture," vol. ix. p. 236), calcareous land, which is composed of forty parts in a hundred of lime, thirty-six parts of sand, and a large portion of clay, is more difficult to till when it has become very damp after a heavy fall of rain, than argillaceous land would be; but when it is dry, this difficulty is considerably diminished.

That proportion of lime in land which is most advantageous to it, is a quantity equal to that of pure clay. Of all the fifty-three varieties of soils produced by artificial combinations experimented on by Tillet, that which appeared to be most favourable to the vegetation of grain was composed of $\frac{3}{8}$ of potter's clay, $\frac{4}{8}$ of shell or fossil marl, and $\frac{1}{8}$ of sand.

The more lime a soils contains, the less sand is required to correct the defects of the clay. But it is highly necessary that some portion of sand should enter into the combination; for without that substance, marl, when dry, would be too tenacious, and when moistened, too soft. General experience confirms the fact, that the proportions indicated by Tillet certainly are the best.

But even when lime is mingled with the superior layer of the soil in so small a quantity that it scarcely appears to have any influence on its consistence, it increases its fertility probably by means of the chemical action which it enters into with the humus and manure. From general experiments and observations, which, nevertheless, cannot be very correct, it appears, that ten parts in a hundred of lime raises the value of argillaceous or clayey soils from five to ten per cent., and even higher, when the land contains a large portion of humus.

On the other hand lime is injurious, when the proportion of it contained in the soil exceeds that of the clay. When the lime is mingled with much sand, it forms a soil too dry and warm, and which, even when plentifully manured, cannot be made to yield good crops of anything but those vegetables which cannot be materially injured by drought, as maize, &c. Chalky soils, which are principally composed of lime, are of this nature, and suffer both from drought and humidity, becoming, in the latter case, sloughy.

When speaking of the soils in which humus forms the chief component part, and in which this substance cannot easily be exhausted, we allude to those which contain more than five parts of it in a hundred; such is only the case, however, in alluvial soils, or those which are formed by the deposit of rivers or of the sea. High grounds and mountainous districts, both those which contain a large portion of clay, and those in which sand is the preponderating ingredient, rarely possess five parts in a hundred of humus, indeed, they seldom contain more than three parts of mild humus, especially at the close of a rotation, when they almost always require fresh manuring in order to enable them to yield profitable crops. The quantity of humus contained in a soil diminishes in exact proportion with the number and condition of the crops derived from it; allowance, however, being made for the manure which it receives. This diminution is not, however, so considerable as it appears or might be expected to be; an amelioration of two hundred quintals of humus leaves, when decomposed, scarcely thirty quintals of dry humus, and this quantity has to be spread over an acre of land, the superior layer of which is generally composed of about 12,000 quintals of earth. Thus, four hundred quintals of soil receive one quintal of manure, that is to say, each hundred receives a quarter of a quintal.

The proportion in which the soil *naturally* contains this aliment of plants and vegetables is, therefore, a very important point; and it is most important that this proportion should be tolerably large, because the less humus a soil contains, the more difficult it is to create that substance in it.

The value of a soil increases in proportion with the humus which it contains. In good clay land I have generally found two parts in a hundred of humus even at the close of the rotation; or, to explain myself more clearly, a portion of the soil which has been submitted to incandescent heat, after having been deprived of its fibrous parts and of its lime, and dried at a temperature a few degrees higher than that of boiling water, has lost that portion of weight. The evaporation of water, most likely, had nothing to do with this diminution of weight, since it is more than probable that the moisture which the clay had previously lost is immediately re-absorbed during the process of weighing.

We shall therefore consider two parts in a hundred to be the average quantity of humus contained in clayey vegetable soils, one and a-half parts as the average in sandy vegetable soils, and one part as the average contained in sandy soils; and we shall take these quantities as a preliminary condition in those estimates already given of sandy and argillaceous lands. The increase of a half-hundredth part of mild humus will augment the value of the soil which contains it five per cent.; thus, land containing two parts in a hundred of humus and valued at 50, will, if it contains two and a-half parts, be worth 52½, if it contains three parts in a hundred its value will be increased to 55; and the same decrease of humus will be attended by a similar decrease in the value of the soil.

The quantity of humus which a soil contains is always taken into consideration even in the ordinary classification of land. It is well known that the same soil is sometimes made to bear barley and at others oats, according as it has been more or less frequently and abundantly manured, and its resources husbanded; thus, whether the quantity of humus has been increased or diminished by the system of cultivation pursued, a clay soil, which is placed by persons well skilled in the classification of land among oat-lands, does not usually contain more than one part in a hundred of humus. Should it contain three parts in a hundred of this substance, or more, and be otherwise exempt from defects, it then becomes second class wheat-land; this addition of humus may be bestowed upon it by cultivation, but that is not so easily done as is generally imagined.

In the first place, I here suppose the humus to be mild, free from all acidity and from all admixture of astringent substances, and consequently soluble. A soil may be very rich in sour or acid humus, and yet barely possess a particle of fertility. We have found five parts in a hundred of humus in a sandy soil of Pomerania, on which four to one of rye was regarded as a fine crop. When submitted to incandescence, it betrayed its nature by emitting an odour like that of burnt turf; and when we came to analyze it more carefully, we found that it contained a considerable portion of acidity. This humus was created by the prevalent method of manuring in that country with a substance partly composed of heath and furze. Such land might, however, be rendered fertile and made to produce beneficial effects by being dressed with an addition of marl.

Land impregnated with a thoroughly acid humus which turns blue litmus paper into a bright red, as marshy land, or soils which approach nearly to peat in their nature, is not adapted for the production of any useful vegetable or plant, and has little or no value; it may, however, be ameliorated without difficulty if there are not any adventitious circumstances to prevent it. Such land is seldom found except in bogs and marshes, or low damp situations, and is generally covered by a tenacious layer of clay. The principal point to be ascertained is, whether there be any possibility of its being drained. When this is practicable, the best method of effecting an amelioration is to pare and burn it. In this operation, one portion of the acid is consumed by the fire and the remainder neutralized by the potassa which the ashes contain, and by this means the land is not unfrequently converted into rich wheat land.

Land which is impregnated with humus resulting from heath or furze, and which is commonly called heath land, produces nothing but furze and plants of a similar nature so long as it remains in its natural state; but it may be rendered fertile by means of paring and burning, by manure, by lime and marl, and by continuous irrigations; the value of it then depends upon the nature of the earths of which it is composed. Sometimes such lands are naturally very good, and their want of fertility is occasioned solely by the plants with which they are over-run, and which themselves prepare the juices which are required for their nutrition. In this case, if the plants are destroyed and those defects are corrected in the humus which render it unfit for the production of useful plants, the land may eventually be rendered exceedingly fertile. The lime and marl which is generally found under the layer of heathy mould, are very efficient auxiliaries. Land of this nature must be valued according to the greater or less difficulties which oppose themselves to the extirpation of the furze and the amelioration of the soil; but where this cannot be effected at all, or at any rate not without great trouble and inconvenience, it cannot be estimated at more than 1.

In this case, however, as well as in others in which it is requisite to make a valuation in order to value the interests of different persons, it must, in my opinion, be considered as a rule, that the soil should only be valued according to its actual state, because those ameliorations which it may be possible to effect in it can only be com-passed by industry, intelligence, skill, and the expenditure of some capital; and those who attempt to calculate the expense or trouble of such ameliorations and improvements beforehand, and the probability which exists of their being attended with success, must invariably fall into errors.

So far as my own experience goes, or the experiments and researches of others lead me to believe, the fertility and quality of those soils which we have analyzed, and their value, may be calculated with precision upon the principles we have laid down, supposing, in the first place, that they are situated in places adapted to their nature, as, for example, light land, rich in humus, on a plain or flat surface, as indeed is generally the case.

If we frequently compare the composition of soils that have been carefully analyzed with such of their external properties as are evident to our senses, we shall, by degrees, acquire the faculty of discovering the nature of this composition simply by attending to their exterior characteristics. Next to colour, the most positive indications of the presence of humus are, a certain lightness of the soil, a characteristic mouldy smell, and the white shoots of the *lichen humosus*. Clay betrays itself by its tenacity and unctuousness. Sand is distinguished by its harshness when rubbed between the fingers, and with still greater certainty by examining the broken and crumbled pieces with a microscope of moderate power; this method is found very useful in determining the quantity of sand which one soil contains more than another, and in distinguishing "black humus." The usual mode of ascertaining the presence of lime in a soil, is by pouring acids upon it and observing whether any effervescence takes place; and the degree of the effervescence is taken as an indication of the quantity of lime which the soil contains, at least until there is time and opportunity to submit it to a more definite analysis.

The soil is indebted for its consistence or cohesion as well to the properties as to the proportion of that earth which forms the predominating ingredient. The explanations which we have to offer on this head will be limited to describing the technical terms by which the degrees of consistence are designated.

Land which, when rather too damp, clings to the plough or harrow in the form of a glutinous paste, which cannot be removed without difficulty, and the detached portions of which form coherent masses, is termed "hard tenacious" or "intractable;" such land cannot be easily divided or penetrated excepting by a sharp or pointed instrument, and the incisions made in it present smooth and shining surface. When dry, it hardens to the density and brittleness of a tile; and the clods, when broken by actual blows, divide into shapeless and lamellated fragments; and it not unfrequently happens that it is impossible to pulverize it at all. When the sun strikes powerfully on such a soil after it has been soaked by heavy rains, the surface becomes indurated and baked hard, while beneath this crust it still retains its humidity; it is then said to be close and compact, and that a crust is formed over its surface: it then contains more than eighty parts in a hundred of clay.

Land is said to be "stiff," "strong," and "heavy," when being dry it may be divided with less difficulty, and breaks into pieces which have a *malt*-like and granulous appearance. Such land can seldom be pulverized either by the plough or spade; those instruments only reduce it to clods which cannot be broken and thoroughly divided except by repeated harrowings; it usually contains more than fifty parts in a hundred of clay.

A soil is said to be "light" and "free" when it forms itself into clods on becoming moistened; but when the clods can be readily divided and pulverized by a slight degree of attrition or pressure, in this case it generally contains from twenty to forty parts in a hundred of clay.

A soil is termed "moveable" or "blowing," when its dry particles have little or no consistence or cohesion, but fall to powder without forming clods. To this species belong all those soils which contain more than ninety parts in a hundred of sand, chalky soils, and those which contain a large portion of humus and but little clay. When the soil is so loose that the wind can easily raise and scatter it about, it is then termed "pulverulent."

The tenacity and degree of cohesion existing between the parts of a soil can be best ascertained by examining it eight and forty hours after a gentle rain. Those who are accustomed to observation can ascertain all they wish to know upon this point by merely driving a stick into the soil, and sometimes even by simply pressing the foot upon it.

In forming an estimate of the value of a soil, an examination of its depth should follow immediately after the examination of its constituent parts. By the depth of a soil, I mean the thickness of the layer of earth which forms its surface, the layer which is usually termed vegetable earth, and which is homogeneous and equally impregnated with humus throughout its whole extent. In most land it descends very little below the depth of that layer which has been recently moved by the plough: when a section is cut vertically, the line of demarcation between the vegetable earth and the subsoil is very apparent. Sometimes this layer is not more than three inches deep; but the usual depth is about six inches; and it sometimes extends ten or twelve inches below the surface. It is only in those places where the soil has been amassed and deposited by the action of water, or where an extraordinary system of cultivation has been carried on, that we find the soil equally impregnated with humus to the depth of one, two, or three feet: six inches may, we think, be regarded as the average depth of the soil; we shall therefore consider, that in order to be exempt from defects, and to be equal to the value which an investigation of its constituent parts leads us to give it, a soil must possess this depth or thickness.

A deep soil contains a larger portion of vegetable earth and of that succulency so necessary to the nutrition of vegetables; and even if this excess of vegetable mould should not be useful to all plants, it agrees with some of them, even when the whole depth of the soil is not turned up. And, besides, this thickness of the superior layer of his land enables a skilful husbandman to draw at will upon the riches which it contains, and occasionally, or about once in six or seven years, to turn it all up and profit by the stores of succulency and nutrition which the under part of it will yield. The roots of all plants sown in a soil of this nature, even those of the tribe of cereals penetrate in a right line, and seek that nutriment at a greater depth, which they would otherwise have had to extend themselves laterally in order to obtain, and they may, therefore, be sown much thicker without causing any detriment to the crop. A deep soil will, therefore, yield much larger crops than a shallow one, provided its nature is similar, and that it is equal in all other respects. The roots of corn are not, as some persons assert, never more than six inches in length: I have seen them exceed twelve inches where the soil was deep enough to admit of such an extension. The roots of vegetables and clover penetrate much deeper in a right line; the same may also be observed with respect to lucern and root crops; land, therefore, in which the layer of vegetable mould is very thick, is peculiarly favourable to the cultivation of these crops. Besides, such land evidently possesses one very great advantage, namely, that of suffering less from humidity and drought. The water which falls upon it has more room to penetrate before it encounters the under-stratum. Argillaceous land, which is tolerably deep, can only be properly drained by means of subterraneous trenches. But as a deep soil can absord and contain more water in its pores, it can also retain it longer, and returns it to the surface from its subterraneous reservoirs when it is required. These soils are peculiarly characterized by their resistance of humidity and drought; and all attentive observers must have remarked that cereals growing in a deep soil are less liable to be laid or lodged even when the ears are very large and that where this misfortune has been occasioned by hail, tempests, or heavy rains, the corn frequently has sufficient strength to raise itself again.

On shallow land, exactly the contrary effect takes place.

These soils are of two kinds: those which are not of a nature to admit being dug more deeply, and those in which, during the process of cultivation, the layer may either be augmented by digging, or by penetrating lower, gradually and successively, with the plough. We shall consider this circumstance again when we come to treat of the inferior layers of the soil.

Soils which have no bottom, or in which the layer of vegetable mould is so thick that it is scarcely possible to reach the bottom of it either by ploughing or by digging it up with the spade, present the possibility of preserving the fertility of a soil without the addition of manure;* the fertility may be equally kept up either by thoroughly digging and raising the soil, or by excavating successively from place to place, and speading those portions of earth over the surface which have been derived from the interior parts. Such soils are, therefore, of an almost incredible value.

But in what proportion does the greater or less depth of a soil increase its value? We have already supposed six inches to be the average depth which a soil ought to possess in order to be exempt from defects on that point, and we are quite convinced that every inch added to the depth of land increases its value eight per cent; so that a soil, where the vegetable layer is twelve inches thick, is worth half as much more as that in which it is only six inches. We are not, however, prepared to say that the value increases in equal proportion when the depth is yet further increased and becomes so great as to render it scarcely possible to reach it by means of simple ploughings; but as the vegetable earth which is beneath the layer turned up with the plough cannot fail to be beneficial to plants, we shall not hesitate to affirm that every additional inch of depth beyond twelve adds five per cent. to the value of the soil.

On the other hand, we should advise that in general the same proportion should be observed in decreasing the value according as the upper stratum of earth diminishes below six inches, which we consider to be the average.

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* At least, until the whole of this vegetable layer has been turned up, brought to the surface, and exhausted.

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|---|---|---|---|
| If, therefore, a soil of | 6 | inches thick is worth | 50 |
| That which is | 7 | inches thick is worth...... | 54 |
| — | 8 | — ...... | 58 |
| — | 9 | — ...... | 62 |
| — | 10 | — ...... | 66 |
| — | 11 | — ...... | 70 |
| — | 12 | — ...... | 74 |
| — | 5 | — ...... | 46 |
| — | 4 | — ...... | 42 |
| — | 3 | — ...... | 38 |

There is no doubt that a soil might acquire this increase of value by means of the artificial deepening or thickening of the layer of vegetable earth. With regard to the expenses with which such an operation would be attended, they vary greatly; at one time exceeding, and at another falling below the value of the increase of depth.

That layer which is situated below the vegetable soil is called the subsoil, under-stratum, or virgin earth. This layer is either composed of the same elements as the superior portion, with the exception, however, of the humus and those matters which are derived from the atmosphere, or it is composed of substances of a wholly different nature. The nature of the subsoil has a considerable influence upon the quality of the upper or superior layer; and the more shallow the vegetable soil, the greater is this influence. The under-stratum which is found beneath clayey or argillaceous land, is usually of the same nature; but is distinguished from the vegetable soil by its crudity, tenacity, and impenetrability. But the same kind of subsoil is not unfrequently found beneath sandy soils in a flat but slightly inclined position; an inferior layer of this nature may tend greatly to ameliorate such land, by preventing the water from settling and saturating the soil with moisture. A portion of this subsoil may occasionally be brought to the surface either by ploughing or digging, and mingled in suitable proportions with the sand. This mixture often appears at first to decrease the value of the soil; but afterwards, when it has been brought more fully into action, the land is found to be sensibly ameliorated.

But when the substratum of an argillaceous soil is rough and uneven, so that the moisture cannot drain off in a uniform manner, and settles and becomes stagnated, it is as likely to become too damp in rainy weather as the more sandy soils.

The subsoil is occasionally found to be of a marly or calcareous nature even in those places where the superior layer of earth does not appear to contain a particle of lime. Here the deepening of the soil by means of ploughing, or of thorough and repeated diggings, produces surprising effects, and ameliorates it in a sensible and double manner; because the marly clay, however tenacious it may appear to be while it forms a portion of the under-stratum, is no sooner brought to the surface and thrown into contact with the atmosphere than it divides and becomes so completely pulverized as to be easily mixed with the soil. Such land is, therefore, susceptible of very great improvement.

A layer of sandy earth is also frequently found beneath an argillaceous or clayey vegetable soil, which, if it is not placed too near the surface, nor at too great a depth beneath it—that is to say, when it is not more or less than a foot or a foot and a half below the surface, and the layer of it is sufficiently thick—produces a peculiarly fertilizing effect upon the soil, rendering it at once warm and solid; absorbing or suffering all the superfluous moisture to run off, and preventing it from ever suffering from an excess of humidity.

Land in which the vegetable soil is shallow above the sand, which constitutes the under-stratum, can bear little or no sun, and is very much exposed to the effects of drought; although it appears to be and is very fertile during a damp temperature, or in spring, while it yet retains the moisture which it has imbibed during the winter months.

Sometimes the layer of sand or gravel is very fine, and situated beneath a layer of impermeable clay. In this case, if the land is perfectly flat, and without any slope or declivity, the water is amassed in this layer of sand as in a reservoir, can find no outlet, and therefore ebbs back to the surface, which it soaks, forms into bog and moist or damp places; such land becomes cold and sterile, because the water in its progress carries with it all those particles of dissolved dung or manure which were not intimately combined with the soil, and deposits them in the layer of sand beneath. This is one of the very worst of all the varieties of soils, and can only be ameliorated by means of complete drainings; by such a process it may eventually be rendered perfectly healthy.

The looser and more porous the subsoil of sand which lies beneath a sandy soil, the drier will that soil be. If after a certain depth the sand possess a certain degree of consistence or cohesion, and the flow of the moisture is thus partially arrested, the soil will be found to be fresher.

Sometimes the under-stratum is composed of rocks or stones, and is then covered with a bed of vegetable earth of greater or less thickness. This latter is often only a few inches thick, as is particularly the case in mountainous districts.

Of all subsoils which are composed of stone, those formed of lime-stone are the best and the most beneficial. At the surface this stone is often rough and harsh to the touch, coarse grained, and full of clefts; it absorbs water, and is not impenetrable to the roots of plants growing in the soil above it. There are some vegetables which appear to attack the stone itself, and can derive a portion of their nutriment from the carbonic acid which it contains; this is particularly the case with sainfoin, and most of those plants which belong to the class diadelphia, and also trees and shrubs; so that calcareous and gypseous rocks are less sterile than others.

Argillaceous schists, covered with a thin layer of vegetable earth, become unloosened when broken by the plough; and the superior layer is thus rendered deeper, and, at the same time, ameliorated. Granite excludes all hope of vegetation; a thin vegetable soil reposing on an under-stratum of this nature will never improve of itself, and can only be ameliorated by additions of manure and of mould.

Sometimes the subsoil is composed of gravel or round pebbles; in this case it is only necessary to ascertain whether they are sufficiently covered with vegetable mould, or whether the superior layer of the soil is too shallow. Under the former circumstances they are not injurious, but rather have a contrary effect; where the soil is of an argillaceous nature they are exceedingly useful by the facility which they afford to the percolation of the superabundant moisture. We shall hereafter speak of those pebbles and stones which are mixed with and lie near the surface of the soil.

Ochre, or steel ore, which is often found below the surface of the soil, is extremely prejudicial to vegetation; and when not covered by a layer of earth sufficiently thick to prevent the roots of the plants from reaching it, may be said to poison it. It is usually covered by a blackish bed of earth, of a brownish hue, and of the same nature as itself: this layer becomes harder the further we penetrate into it; and at last is found to be compact as a stone. Trees perish as soon as their roots touch this earth.

With regard to humidity, we shall divide the subsoils into the free or porous, and the close or retentive. The former species is sandy, and frequently stony, and rarely without clefts or openings through which the water can percolate. The less sand this layer contains, the more impermeable does it become; however, it not unfrequently happens that we find clay which contains a great deal of sand to be wholly impermeable as soon as it becomes hard. Thus, when it is always ploughed to an equal depth, the pressure of the sole of the plough and the tread of the horses gradually forms a hard crust, which is brittle and impermeable to water;* while the soil above and below is loose and permeable.

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* The moorband pan of the English farmers.

In by far the greater number of cases, we find that the too great humidity of a soil is entirely caused by the impermeability of the under stratum; for, although the superior layer may be more or less retentive of moisture, or naturally more or less liable to suffer from damp or drought, this does not appear to be injurious to vegetation; at any rate, so long as no more moisture is contained in the soil than the earths of which it is composed can take up and absorb by means of their cohesive attraction for water. But where the moisture cannot evaporate or drain away, but soaks and saturates the land, rendering it like a thick paste, there is scarcely any plant we cultivate which would not be injured by such an excess of humidity. When the sub-stratum is impermeable, and, instead of forming a kind of inclined plane, and thus affording a channel for the water to drain away, is uneven and full of furrows, the water settles as in basins or reservoirs; and the land can only be dried and rendered healthy by means of evaporation, or of artificial draining. Those springs which rise in some soils are usually created by the nature of the sub-strata.

This excess of humidity may also be produced by water which runs from the surface of higher grounds, and, finding no ulterior outlet, settles and injures the land. And, lastly, it is occasionally caused by the overflowing of neighbouring rivers and lakes.

We shall enter more fully into this subject when we come to speak of draining and the drying of land; and shall only allude to it here on account of the influence which the greater or less difficulty there is in overcoming and obviating this defect has on the land. Sometimes humidity renders land unfit for almost every purpose; at others, it is highly favourable to the vegetation of herbage, and renders the soil peculiarly well adapted for meadow and pasture land; but it never gives it those qualities which fit it for the cultivation of corn. Occasionally, it admits of spring corn, and especially oats, being sown; but never autumnal corn.

The spring is the best time to form a correct estimate of the injurious effects of the moisture with which the soil is impregnated. Traces of it are evident enough in the plants which vegetate there at all seasons; but they are more equivocal. The best time to form a judgment of the disposition of a soil to retain moisture is some few days after a gentle rain; it is then termed—

(*a*). Very dry, when on being squeezed in the hand it does not afford the slightest trace of moisture.

(*b*). Dry, when it only betrays moisture on being forcibly squeezed.

(*c*). Fresh, when its moisture is easily apparent.

(*d*). Humid, when it moistens the hand on being slightly compressed.

(*e*). Wet, when on being squeezed the water oozes out by drops; and when a clod of earth turned up with the spade, or a furrow made by the plough, glistens with moisture.

(*f*). *Aqueous* or *marshy*, when the water stands on the surface, or rises into those hollows which are indented by the pressure of the foot.

By the temperature of a soil, or what is termed its *warmth* or *frigidity*, we do not mean that degree of heat which is communicated to it from the atmosphere, or by the solar rays, and which is dependent on climate and situation, but merely that which is inherent in the soil itself.

Our globe appears to contain within itself a certain degree of caloric. In fact, at the depth of ten feet below the surface of the soil, the temperature always remains equal to seven degrees of Reaumer's thermometer. This heat was for a considerable period thought to be produced by some central fire contained in the bowels of the earth; or at any rate, by some great amount of caloric which has existed there from the time of the creation, and which, as it approaches the centre of the globe, becomes gradually more and more intense. But this opinion has been proved to be totally without foundation by the fact that, however deeply we penetrate during the process of mining, no increase of temperature has yet been discovered.*

At the depth of 1,200 feet below the surface of the soil, the heat is always the same; it is only in some mines in Hungary where any elevation of temperature has been perceived: but this circumstance may be attributable to local causes, such as the elevated temperature of some springs, or the peculiar nature of the surface of the ground which they flow over. The caloric resulting from these subterraneous furnaces is a phenomenon that seldom occurs.

The differences or variations in the temperature of the soil are often distinguished from one another by the greater or less period which snow laying on them takes to melt, and by the greater disposition which some places have to freeze than others, independent of their position: this cannot fail to have considerable influence upon the autumnal and spring ploughings. Some observations have lately been made on this subject with the help of a thermometer, but they have neither been sufficiently definite nor repeated often enough for me to be able to assert anything more positive on the subject than the following remarks upon the causes of these variations of temperature.

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* This remark appears hardly to accord with more recent geological observations:—

"The first investigation of importance that presents itself," says a writer in the "*Polytechnic Review*," is the thickness of the crust on which we dwell. We have seen by the theory that this ought to be continually increasing, though with increasing slowness, and that there was a time when it was so thin as to be almost in a state of fusion. We have stated that the increase of temperature observed is about one degree Fahr. for every fifteen yards of descent. In all probability, however, the increase will yet be found to be in geometrical progression, as investigation is extended; in which case the present crust will be much thinner than we have calculated it to be; and should this be found to be correct, the ingenious theory will become a subject of more importance, in a geological point of view, than we are at present disposed to consider it. Taking, then, as correct the present observed rate of increase, the temperature would be as follows:—

Water will boil at the depth of 2,430 yards.
Lead melts at the depth of 8,400 yards.
There is red heat at the depth of 7 miles.
Gold melts at 21 miles.
Cast iron at 74 miles.
Soft iron at 97 miles.

And at the depth of 100 miles there is a temperature equal to the greatest artificial heat yet observed; a temperature capable of fusing platina, porcelain, and indeed every refractory substance we are acquainted with. These temperatures are calculated from Gyton Movern's corrected scale of Wedgewood's pyrometer; and if we adopt them, we find that the earth is fluid at the depth of 100 miles, and little more than the soil on which we tread is fit for the habitation of organised beings."

The temperature of a soil, in the first place, evidently depends upon its humidity. Damp, wet land is generally cold; it dries very slowly, freezes rapidly, and takes a long time in acquiring the amount of heat necessary to support vegetation: it is, on this account, designated by the terms *moist*, and *cold;* dry soils are termed *warm*, and those which are very dry are called *burning*. There is no doubt that this arises from the water absorbing a considerable portion of the caloric contained in the soil during the process of evaporation. Occasionally, however, it happens that we find sensible differences existing between the relative temperatures of soils which possess an equal degree of humidity. Land which contains a considerable portion of mould, or manure which has not been exhausted, or other substances in a state of putrefaction, is much warmer, and melts snow which falls upon it much sooner than would be the case under other circumstances, so that country people are accustomed to say that such land *devours the snow*. There can be no doubt that this heat arises from the chemical decompositions which are going on in the soil, and in the process of which a considerable degree of caloric is almost always evolved; and it is evidently by no means a figure of speech to say that manure warms the land. It acts upon it mechanically by rendering the soil lighter, looser, and therefore dryer; and chemically by decomposing it.

Calcareous soils are always warmer than others, because they accelerate those chemical decompositions, and because they not only act more powerfully and promptly upon the manure and humus, but these latter, in their turn, act upon the soil. All soils are not equally good conductors of the heat which they receive externally; sand, when not too much saturated with moisture, is a better conductor than clay. Thus, a sudden change of temperature affects plants vegetating on a sandy soil much more than those which are growing on argillaceous land; and this is the reason that night frosts, and especially white frosts, are more injurious to the former than they are to the latter: probably some of the subsoils communicate that caloric which is engendered in or exists in the land, to the bodies with which they come in contact, much sooner than others do, and thus counteract the frosts, and prevent them from penetrating very deeply.

The degrees of temperature possessed by the soil are designated by the following terms:—

(*a*). Burning.
(*b*). Hot.
(*c*). Warm.
(*d*). Cold.

The value and qualities of a soil do not depend solely upon its composition and the nature of its constituent parts, but are also influenced by its *position*, *form*, and *situation*, and by the *nature of the surrounding localities;* all of which circumstances tend to modify its worth and utility.

The *form of the surface*—the fact of its being hilly or flat, horizontal or inclined, tends to increase, or detract from the value of land, according to the proportions of elementary earths of which it is composed.

Loose, dry, sandy soils, are most fertile when they are flat, and when they are situated lower than the surrounding country. In this position they retain moisture for a considerable period, and yet rarely possess a superabundance of it. On the other hand, such a soil decreases in value when situated on declivities, hills, or on the sides of mountains: in these situations its moisture rapidly drains away, and is not only thus lost, but is also caught along with the fertilizing particles of mould or humus, and blown away by the wind. In such a position, a sandy soil, which, if situated on a plain, might have been cultivated with success, is scarcely worth the labour attendant on sowing it; and it not unfrequently happens that it is dangerous to break up the superior layer of such land, if we would not have the neighbouring country inundated with whirlwinds of sand.

An argillaceous soil, the substratum of which is impermeable, will be improved by being situated in an inclined or mountainous situation, because the superabundant water is enabled to run off. In such a situation, all the inconveniences attendant on an excess of humidity may be obviated by means of judiciously disposed furrows and trenches: nevertheless, stiff clayey declivities are never desirable on account of the difficulty attendant on their cultivation.

The proportion in which the soil is elevated above the level of the sea has considerable influence on the climate and atmospheric temperature. Even under the same degree of latitude, the heat is always greater on plains and flat surfaces than on mountains: there is no place, until we reach the torrid zone, where the tops of the highest mountains are not covered with perpetual ice and snow. The nearer we approach the equator, however, the more do we find this ice and snow confined to the summits, but it extends lower and lower as we come nearer the polar circle. Vegetation likewise diminishes in exact proportion with the heat: those trees and vegetables which grow on high mountains are always stunted; if we ascend higher still, we find only firs and alpine plants; and as we approach the top, only a few mountainous plants are here and there visible; and finally, all traces of vegetation disappear.

A sensible diminution in the vegetation of cereals is perceptible at very inconsiderable elevations, even when the position is otherwise advantageous; provided, however, that the soil is calculated for it, wheat always thrives better than rye on hilly or mountainous situations, and oats better than barley. There is seldom any want of humidity on mountainous lands, for they are usually depots for the reception of the moisture which is contained in the atmosphere; and this is one great reason that cereals do not thrive so well here as on flat soils, warm, dry land being always more favourable to them than that which is cold and damp. But as there is generally a sufficient degree of declivity to allow of water running off, it is always practicable to drain the land by digging furrows to carry away the superabundant fluid.

One circumstance which militates considerably against the value of land situated on mountains, hills, and declivities, is the difficulty of carrying manure to it. Some persons have considered that this objection might be obviated by grazing with cattle, but the difficulties attendant on the operation of ploughing would thus be considerably increased. Lastly, heavy rains and torrents often carry away with them the whole, or, at any rate, the greater part, of the vegetable soil from hills and declivities. It is, therefore, generally advisable to allow all land thus situated, however capable it may be of producing rich harvests, to be planted, or to remain as forest or woodland.

On the declivities of mountains and hills, as well as on slightly inclined plains, the direction of the inclination is a very important point.

It is a very difficult matter to dry and warm land which looks to the north. Those vegetable and animal substances which afford nutrition to plants are not decomposed without great difficulty, and are much longer in attaining the requisite degree of fermentation. Neither does the period of vegetation last so long: it commences much later, and finishes much earlier. The plants feel the want of light and heat; they are less savoury, yield less fruit, and frequently suffer materially from cold winds and frosts.

Land which has a southern exposure is more easily warmed; it enjoys a greater degree of light; vegetation commences much earlier there, and attains a far greater perfection. On the other hand, such land is much more liable to suffer from drought, and is much more exposed to the pernicious effects of those storms of hail and rain which come from this quarter.

Land which inclines towards the east is very easily drained; the atmosphere deposits less humidity on it. The morning sun calls forth all the powers of vegetation much earlier, and brings into action all those matters which have been absorbed and have lain dormant through the night. The crops sown in these situations rapidly progress and arrive at perfect maturity; but it cannot be denied that they are very liable to be destroyed by cold nights and white frosts. These last-mentioned evils are, however, less injurious in these situations than they would be elsewhere; because the morning sun touches them sooner, although, from possessing less power at that time, it does not cause so rapid an evaporation of the dew.*

In land that inclines towards the west, the vegetation does not receive its light and heat immediately from the sun, until all the night dews and moisture have been evaporated, and those vital powers which were reanimated by rest have again become weakened; the products, therefore, which grow in this situation, are not usually very forward, and never attain so high a degree of perfection as those which receive the rays of the morning sun. Westerly winds generally convey a considerable portion of wet and moisture: therefore, land which inclines in this direction is less liable to suffer from drought. A slight inclination towards the south of the west is a much more advantageous position. The evils occasioned by sudden thaws are most sensibly felt in these situations, because the sun does not reach the plants until it has attained its utmost altitude and its rays possess the greatest power.

The advantages and disadvantages of these various positions are considerably influenced by the composition of the soil and its other properties. Cold, damp, argillaceous land is improved by exposure to the east and to the south; and very much deteriorated in value when it faces the north or west. Sandy or calcareous soils, on the contrary, are improved by being inclined towards the west, as are all dry, warm soils; and are proportionally deteriorated by facing the south or the south-east. An inclination towards the north can never be advantageous, especially when the declivity is so abrupt that the sun's rays only reach it in an oblique direction.

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* In the country in which I reside, it has been remarked that those portions of land which receive the first rays of the morning sun are more apt to suffer from the effects of white frosts than others, because the sudden transition from cold to heat sensibly affects delicate plants.—FRENCH TRANS.

It occasionally happens that land is deprived of light, and the rays of the sun are prevented from reaching it, by the intervention of surrounding objects, as forests, mountains, large trees, or buildings. Now, leaving the heat imparted by the rays of the sun wholly out of the question, the light is in itself indispensable to the welfare of plants, and is, in all probability, an active agent in accelerating certain decompositions which are constantly going on in the soil.

We know that all plants seek the light, and invariably turn in that direction from which they can derive the greatest portion of it. This is quite evident in those growing in the open air, but still more so in rooms and confined spaces; and it may be still further tested by enclosing vegetables in wooden boxes, into which light is only admitted through a cleft in the wood; the strength and eagerness with which these plants force themselves into the clefts in search of that invaluable aliment to them, light, is almost incredible. In thick plantations, whether of trees or vegetables, the whole force of the vegetation is pushed upwards, and each one seems to vie with the other which shall obtain most light.

There is not the least doubt that vegetation is always higher in thick plantations, but at the same time the lower parts are weakened by this rapid growth. All plants that grow in obscurity or in shady places, have a dull, sickly look; their tissue is weak and colourless; their shoots long, thin, flabby, and easily broken; they have not their proper flavour, and their juices are insipid and watery. On the other hand, the more intensely and vertically the rays of light fall upon plants, the stronger do these latter become, and the more perfect and vigorous are all their parts. The green hue of the leaves is produced solely by the action of light; and this accounts for those which are not fully developed, or only just bursting, being pale and colourless. Various experiments tend to prove that this particular effect of light is totally independent of the heat which is transmitted at the same time by the rays of the sun; a strong artificial light has been found advantageously to replace sun-light, provided that the temperature is otherwise the same.

It cannot be denied that plants germinate in land which is overshadowed; indeed, a sheltered position is rather favourable than otherwise to their germination; but in such cases they only attain a partial degree of development, do not yield much nutritive matter, and their fruit seldom reaches maturity. Grass which grows under trees the branches of which meet together affords little nourishment to cattle.

The nature and composition of a soil can alone enable us to decide whether it is most advantageous for it to be exposed to the action of all the winds of heaven, or sheltered by hills, mountains, forests, buildings, or hedges. Damp, argillaceous soils are much more benefited by exposure to the open air than by being sheltered from the action of the wind. Where they are in a sheltered position, the snow does not melt so soon, and the land takes much longer time in drying, especially in the spring. On the other hand, dry, sandy, warm soils are often materially benefited by being sheltered from the wind, and may often be considerably improved by being surrounded with hedges, or protected by a plantation of trees on that side whence the wind the effect of which would be most prejudicial may be expected to blow. Wind is, in general, very injurious to land of this nature, drying up all the moisture which it contains, and scattering abroad the upper layer of earth and the humus which is mingled with it, and laying the roots of all the plants in one place quite bare, while in another it buries the whole of the vegetation under a cloud of rough sand.

With regard to the plants themselves, wind acts differently on different kinds. In some it facilitates the fructification, while in others it tends to oppose it; the latter, therefore, seldom yield much seed unless they are planted in sheltered spots.

Lastly, it is also necessary to take into consideration the nature of the atmosphere and temperature which constitute what we term a climate. If this climate is such as the latitude would lead us to expect, and the average temperature of the atmosphere is suitable to it, there is no need of our inquiring further into this circumstance, all things then being in their natural state.

But the numerous modifications in the state of the atmosphere and of the temperature which are observable in some districts and in isolated portions of land, render it absolutely necessary that we should enter more fully into this subject than we have hitherto done.

The different degrees of warmth or heat of which we are sensible are not solely attributable to the solar rays, or to their direction being more or less vertical; there are many other circumstances which appear to tend, in a greater or less degree, to produce these effects. The decomposition which is constantly going on in the atmosphere; the influence of exhalations which emanate from the surface of the earth; that interchange of temperature between neighbouring lands which is effected by means of the currents of air; the number, size, and extent of the mountains or forests which environ or intersect a country, and protect it against the cold, or refresh it by means of their frozen summits; the relative height of a country; the proximity of the sea or of large rivers or lakes; a sandy or a marshy soil—all these are circumstances which deserve consideration, as tending to exercise considerable influence on the local temperature.

That fluid which is suspended in a state of aeriform solution in the atmosphere, is precipitated much more abundantly in some places than in others. As yet, we have not any accurate meteorological observations or exact data with respect to the quantity of rain which has fallen in different districts or countries; nevertheless, such observations always must be peculiarly interesting to an agriculturist.

We have already stated that the summits of mountains have a far greater tendency than plains or flat surfaces to attract the fluid contained in the atmosphere. Independent of this consideration, the attraction of the aqueous vapours is far greater in some places than it is in others; they precipitate themselves in the form of heavy dew, fogs, or rain. Those districts which are situated near the sea or to lakes, or even to large rivers, receive a larger quantity of vapourized water, and are in general much damper than others; especially if these lakes or rivers are situated to the west of the land. This circumstance frequently tends to ameliorate dry soils, rendering them adapted for the growth of herbage; but it detracts in no trifling degree from the value of such land as was previously inclined to humidity.

Those vapours which are exhaled from standing pools of stagnant water, and especially those given out by marshes, often possess very deleterious properties; the fogs which they engender frequently empoison whole plains so completely, that every year the cereals grown on them are attacked by various diseases, and yield but a scanty produce in grain, although the crop may have looked well and healthy in the spring. It is quite evident that the evil arises from this cause, because after the land has been thoroughly drained, the crops will always be found to thrive.

Extensive forests of lofty trees also appear to attract moisture, or, in other words, to condense the water which is held in a state of aeriform solution by the atmosphere; in fact, it has been generally remarked that a larger quantity of rain falls in well-wooded districts than in others.

Lastly, there are countries in which the clouds gather much more than in others. This has been attributed to their sometimes following the course of rivers, at others gathering over neighbouring heights, or receiving their direction from chains of mountains. Some countries almost always receive the brunt of those storms which have risen in certain quarters; while others seldom or never suffer from them, or at any rate sustain very slight attacks. As storms of rain are in general rather beneficial than otherwise, the former places are distinguished by their fertility, although at the same time they are more exposed to the devastations occasionally produced by hail.

The atmosphere generally, and the inferior strata in particular, do not contain water alone, but various other substances which have considerable influence on vegetation, and these substances enter into its composition in various proportions. It is well known that carbonic acid gas, as well as carbonated hydrogen, sulphuric, and phosphoric gases, are exceedingly favourable to vegetation, and contribute materially towards the improvement of the soil. But it is probable that the atmosphere also contains other and more compound substances, especially emanations from partially decomposed animal bodies. Extremely populous countries, in which a great number of cattle are kept and an immense quantity of provisions consumed, and in which numerous decompositions are constantly in operation, and the emanations from which combine with the atmosphere, are peculiarly remarkable for their fertility; and numerous observations seem to prove that this extraordinary fertility is totally independent of the extra amount of manure which can be applied to the land in these countries.

In large towns and their environs, this influence of the atmosphere on the fertility of even the worst kinds of land, cannot be mistaken. Those observations which were made in the preceding section on the vapours which emanate from stagnant water, prove that the atmosphere is capable of containing deleterious as well as beneficial matters. Incontrovertible experiments have demonstrated the pernicious influence of the barberry on all kinds of cereals growing near it.

The value of a soil may be considerably modified by the greater or less quantity of weeds that it contains; I say the greater or less quantity, because we seldom or never find a soil entirely exempt from this defect.

All those plants which vegetate in any spot where it is not desirable that they should exist, are termed weeds, because they injure the crops which are cultivated there, by usurping their place, and depriving them of a portion of that aliment which was destined for them, and by accelerating the exhaustion of the soil. We shall, however, here confine ourselves to those kinds of weeds which so completely choke the soil with their roots and seeds as to render it impossible to get rid of them without great labour, difficulty, and considerable sacrifice; and which exercise an evidently prejudicial influence on the success of the crops.

1. Those which propagate themselves solely by means of their seeds.
2. Those which are multiplied by means of the suckers from their roots.
3. Those which are re-produced by one or both of these means.

*Those weeds which are re-produced by means of their seeds* may be divided into two classes: the *annuals*, or those which spring up, produce, and shed their seed in the same summer, and then perish; and the *biennials*, which spring up the first year, live through the winter, and produce their seed in the second year of their vegetation. Neither of these two classes possess long-lived roots; the whole plant perishes as soon as the seed has reached maturity.

The seeds of weeds appertaining to the classes of which we are now speaking are of such a nature as only to germinate when very near the surface of the soil where the atmosphere can act upon them. When situated at a greater depth, or enclosed in clods of earth, they do not germinate, but remain healthy, and preserve all their vitality until brought into a position which is favourable to their development. There does not appear to be any limit to the period during which this seed can preserve its vitality; for when we come to plough up land that has remained uncultivated for an unknown period of time, and in which no traces of weeds had ever been observable, it suddenly becomes covered with them. Thus, in the marshes of Oder, an amazing quantity of wild mustard (*sinapis arvensis*) will shoot up, when some portion of land which the oldest person cannot recollect having been anything but a marsh is ploughed up, and the turf thoroughly destroyed and divided. The seed whence this plant is produced must have been brought there at some remote period, and deposited in the mud by the action of water. It has often been observed that weeds of this nature spring up in earth that has been dug from several feet below the surface of the soil, and even from the ground which formerly constituted ancient forests. A blackish earth was found beneath an old building, which certainly had existed for upwards of two hundred years, and was transported to a garden to mend the soil; a quantity of *chrysanthemum segetum* (corn marigold) sprang up, although this weed had never before been seen in that place. The frequent recurrence of these and similar phenomena has led many persons to believe that these plants were spontaneously produced by nature without the intervention of either seed or germ, as if it were possible that there could be a single exception to the universal rule, "*omne vivum ex ovo.*"

The immense number of minute seeds that can exist in a soil is beyond all comprehension. When a portion of land is carefully divided and reduced to powder, it speedily becomes covered with a thick bed of weeds, which is easily destroyed by the action of the plough; but the second portion of earth which is brought to the surface soon bears as plentiful a crop as the former one. I have seen this occurrence at least six times following in the course of one summer, without being able to remark any diminution in the crop of weeds which succeeded each ploughing, and without the species being destroyed in the following year. These operations have been constantly repeated for three years without the seeds of the weeds being entirely extirpated.

Those weeds which belong to the class of *annuals* in general only show themselves among the spring corn; the autumnal cereals are often entirely free from them, especially when the sowings have been performed sufficiently early to admit the development of the seed which was situated at the surface of the soil. This class of weeds cannot resist the winter; they invariably perish in the spring if not before. They are only found among the autumnal corn when the surface of the soil has been turned over afresh, or when it has been carefully reduced to powder, or the clods not broken until winter or spring, or, lastly, unless the seeds are deposited there by the action of wind or water; and even in these cases the weeds are never very plentiful, unless an unusual mildness of temperature has preserved them throughout the winter. The *biennial* weeds, on the contrary, do not attain their perfect developement but with the autumnal crops, although they also spring up among the spring corn.

The most numerous of all the species of *annual weeds* are those which belong to the tribe of wild mustard and will radish plants; various kinds of plants are included in this number, although the appearance of all is very similar. The wild mustard *(sinapis arvensis)* only thrives on strong, rich, moist soils; this plant, so far from attaining maturity on poor land, soon perishes there; indeed the seeds of it may be sown in such places with perfect impunity. It certainly springs up on poor land, but then it is speedily choaked by other plants; whereas it completely overruns rich soils, and those which are strongly impregnated with humus, and injures if not entirely destroys the crop. This plant may easily be extirpated, because its seed not being enclosed in a thick, hard covering or husk germinates with great facility; neither is it altogether useless because, perishing at the same time with the spring corn, its seed may be reduced to oil after having been separated by means of a sieve. Careful agriculturists always pull this plant by hand in its full vigour, before the cereals reach to any considerable height, they then give it to their cattle for fodder, and it is found to be very profitable for that purpose.

The wild radish or jointed charlock *(raphanus raphanistrum)* vegetates on sandy clays or clayey sands; and on all weak soils, however unfavourable the temperature may be, it is found to flourish; the weaker the soil, and the more unfavourable the weather, the sooner does it check the cereals. It is particularly distinguished from the wild mustard by the tough and membranous cuticle which envelops its seeds, totally preventing the extraction of oil, or at any rate rendering it difficult; besides, the seed is smaller and not so oleaginous in its nature as that of the wild mustard; the stalk is rougher to the touch and more devoid of nutritive juices than that of the last named plant. It is, nevertheless, nourishing and agreeable to cattle; therefore fields infested with this plant are not altogether valueless, as they may be made to yield a good supply of fodder without the necessity of sowing any more seed, but simply by means of ploughing and harrowing them several times in the course of the summer.

Land is also occasionally infested by various species of cabbage, cole, and some varieties of rape seed.

For some years past these kinds of weeds have appeared to increase rapidly on the arable land in the north of Germany; in fact, it is now almost impossible to find a single field that is exempt from them. This evil may be chiefly attributed to sufficient care not having been taken to procure the seed with which the fields are to be sown quite pure; even these precautions will not, however, be always effective, as in many cases the land already contains a great quantity of these pernicious seeds. These weeds can only be diminished and extirpated by turning up the soil frequently during the summer months, deferring the spring crops, and, lastly, by pulling up all those plants with the hand which have otherwise escaped destruction, and which spring up in various places.

The corn marigold (*chrysanthemum segetum*) is a much more pernicious weed, but it is not so plentiful as the others. It grows so vigorously, is destroyed with such difficulty, and multiplies so rapidly and numerously, that it not unfrequently renders a soil totally unfit for the production of spring corn, and deprives it of all its value. This plant does not germinate until very late, and until the soil is tolerably warmed; but then it shoots up so vigorously that it soon chokes all those plants which had attained a tolerable degree of vegetation before it began to sprout; its strong vigorous shoots and leaves rapidly extend themselves over the whole surface of the ground, and appear to absorb all the nutritive matter contained in the atmosphere as well as in the soil. It possesses so great a degree of vitality, that if one of the plants be plucked while yet in the bud, the flowers will not only open and blossom, but even the grain will arrive at maturity. When a field is weeded, and these plants are pulled up and thrown together in a heap, they do not enter into decomposition or fermentation; on the contrary, those at the top of the heap shoot again, vegetate, and bear seed: so that the only way to destroy them is to bury them very deeply, or to burn them. The seeds of this plant will pass through the bodies of animals without losing their vitality, and thus the "chrysanthemum" is frequently propagated by means of the dung. In districts where this evil is known to exist in the neighbourhood, but to which it has not yet extended itself, the most unremitting pains and precautions are taken to ward it off. If any horses or cattle come from places infested with this weed, all the excrements which they void are immediately burned, and the farmers refuse to purchase hay or straw which is likely to be thus contaminated. In order to prevent the multiplication of this plant, rewards are frequently offered for every corn marigold that is plucked up and destroyed.

When land is once overrun with this plant, it is extremely difficult to destroy it; especially in crop-lands where different properties are intermingled, it cannot be done without very great sacrifices; nevertheless, it is not so thoroughly impossible as many persons seem to think. Frequent summer ploughings and harrowings which always turn up a fresh bed of earth to the surface, destroy a great portion of the seed after its germination; this end cannot, however, be attained in one summer, even if the land is ploughed every third week. Spring corn must not be sown between the two fallows; nor must any other produce be raised among which the "chrysanthemum" can possibly spring up and attain maturity, unless repeated and most careful weedings are bestowed on the crop.

Two examples cited in the "Annals of Agriculture of Lower Saxony," Vol. iii. p. 320, prove that if the proper degree of attention is paid, and the requisite care and precautions used, this evil may eventually be removed; but of course the value of a soil infested with this weed is depreciated in proportion to the difficulty in extirpating it.

Another plant which is equally injurious, but which is more easily destroyed, is the wild-bearded-oat (*avena fatua*). It usually grows among the spring corn; but is also often found among the autumnal crops. As its seed does not remain long in the earth, but easily germinates, and shoots when just below the surface of the soil, it may be entirely extirpated from a field in the course of a year, provided that as soon as it flowers, it is immediately cut down and given to the cattle, or stacked as dry fodder, a purpose for which it is well adapted: but if the seed is allowed to ripen and come to maturity, it readily drops out and sows itself before the cereals have attained their full growth. The seed of this plant is easily carried away by the winds, and freed from its husk or cuticle; the grains are so much disposed to become dilated by moisture and contracted by heat, that they have been used as a species of hygrometer. The seed of this plant is very frequently conveyed with the seed corn from a field which is infested with it, to another which had previously been wholly exempt; in districts where this plant has once established itself, it is scarcely possible to extirpate it unless all the farmers join together in endeavouring to effect that purpose.

Among those weeds which resist the severity of winter, and which consequently are chiefly found among the autumnal corn crops, the corn blue bottle (*centaurea cyanus*), the various kinds of camomiles (*anthemis, anthemis cotula, anthemis arvensis*), the ox-eye daisy (*chrysantemum leucanthemum*), the cocks-comb (*crista galli*), the yellow-rattle (*rhinanthus cristagali*), the corn or red field-poppy (*papaver rhoeas*), the corn-cockle (*agrostemma githago*), are those which recent experience has taught us can exist for the greatest length of time in a soil without germinating, although their seed is of a tolerable size. The seed of all these plants preserves its vitality so perfect while imbedded in the earth, that the utmost endeavours are frequently insufficient to free the soil from them. They are not, however, so injurious to the autumnal as some others are to the spring corn, because in the first named crops the cereals being vigorous and thick, and vegetating upon a healthy rich land, soon get the upper hand: these weeds only thrive and spring up abundantly where the vegetation is weak and feeble.

The same may be observed with respect to rye-brome grass (*bromus secalinus*); its seed is frequently mixed and sown with the corn accidentally; but it often lies embedded in the soil, where it remains for an immense period of time, without shooting or germinating, unless it is brought to the surface of the soil. It often happens that when wheat which was considered as perfectly pure has been sown, more brome-grass than wheat has sprung up; whence has arisen the absurd opinion, that rye can be transformed into brome-grass. This plant thrives in those places where the land is so damp as to be prejudicial to rye, and becomes so strong and flourishing as speedily to choke the grain. In dry seasons an exactly contrary effect takes place; therefore, in dry situations and seasons there is scarcely any appearance of this weed, although the seeds which have been scattered over the land retain all their vitality. I shall pass over a number of other weeds which are propagated by their seeds, but which are neither so common nor so injurious in our climate as those I have already mentioned; neither shall I mention those which proceed from seeds sown accidentally among the cereals, or from seed preserved in the soil, all of which can be entirely extirpated by proper care and attention; as wild vetches (*vicia cracea*), the tufted vetch, the yellow vetchling (*lathyrus aphaca*), the rest-harrow (*ononis arvensis*).

Among the weeds which are seldom propagated by their seeds, because these latter rarely attain maturity, and which, nevertheless, overrun whole fields, and materially injure the land, we particularly notice couch-grass (*triticum repens*), and marsh-bent-grass (*agrostis*). Every agriculturist must be aware how very difficult it is to extirpate the former of these weeds in a field that has once become infested with it, especially if the substratum or the situation of a soil renders it liable to suffer from humidity; in such a case the utmost care and pains bestowed on the fallow is often ineffectual. We shall point out the best means of destroying these weeds when we come to treat of ploughing, or breaking up and loosening the soil; at present, all that we have to consider is their influence on the value of land. So long as a soil continues to be overrun with couch-grass, it will not bear those crops which might otherwise be derived from it. Land thus infested is generally not poor, and it is still further improved by the putrefaction of the roots of this weed. If, therefore, it can be fallowed at once, or only made to bear those crops which require careful weeding, a judicious agriculturist will find that he will not have to make greater sacrifices on it than on other land, he will only have to plough and harrow it rather oftener; but in forming a valuation of such land all these circumstances ought to be taken into consideration.

This evil is not so important to those who are about to purchase a farm or estate, as it is to those who are merely about to rent one, especially if they are only taking it on a short lease. Where the fields are damp, infested with couch-grass, and consequently cannot be cleared without difficulty, their intrinsic value is of course considerably diminished.

Lastly, among the most injurious of all the weeds that infest our fields is the corn-bind weed *(convolvulus minor,* or *arvensis)*, the roots of which penetrate so deeply into the soil that it is almost impossible entirely to destroy it. It injures the cereals as well by its large leaves as by its long shoots, which entwine themselves round the blades of corn and drag them downwards.

The varieties of horse-tail *(equisetum)* mostly vegetate on soils in which the substratum is always damp; they do not appear to be very injurious to corn, unless by depriving it of that amount of space which is occupied by the blades of this weed; it absorbs little or no portion of the nutriment which the cereals ought to receive, because this plant derives its nutrition from the subsoil. Horse-tail is, however, very prejudicial to pasture land, both because cattle do not like it and because it is not wholesome for them.

Coltsfoot *(tussilago, farfara,* or *petasites)*, with its broad leaves, extends over a large surface, and can only be got rid of, with great difficulty, by means of incessantly digging up, tilling, and draining those soils in which it has once taken root; it generally grows on argillaceous and marly soils.

The dew-berry *(rubus cesius, fructo nigro, rubus fructicosus)*, or the shrubby bramble, often extends itself very rapidly; it flourishes most on soils which contain marl or clay. It is very difficult to destroy this plant, because its roots penetrate so deeply into the soil, and each of them puts forth new shoots, which spring up in various places, and choke and destroy the cereals.

Among that class of weeds which are propagated both by means of their roots and their seeds, we find the corn-thistle *(seratula arvensis)*, particularly eminent. This plant will seldom grow in any but rich clayey soils, and its presence may therefore be considered as an indication of fertility. Nature appears to have made a special provision for the preservation of this plant, by providing it with prickles, which prevent the cattle from touching it after it has attained a certain size. Numerous stalks and shoots spring from each of its roots, and the more these are cut while young, the more rapidly do they multiply. Besides, it produces an immense number of light downy seeds, which are carried about, and disseminated far and wide by the winds, and thus sow themselves. A soil may become so infested with this weed as to cause all the crops sown on it to fail or to be greatly injured.

The various kinds of docks *(rumex)* also extend themselves over the fields, and their great and rapid multiplication is owing quite as much to the shoots thrown out by their roots as to the seeds.

There is an immense number of weeds, but we shall here content ourselves with pointing out those which are most liable to injure the crops which are raised on arable land; at some other time, we shall speak of those which infest and injure meadow land.

We occasionally find certain fields or portions of land to be full of stones. These, considered in an agricultural point of view, may be divided into two classes: first, those which cannot be removed by the operation of ploughing; and, secondly, those which are loose and detached.

Those large stones which show themselves on the surface of land, and, what is still worse, those which are so covered with the vegetable soil as not to be perceptible, are exceedingly prejudicial to all the operations of tillage. They are sometimes at so great a depth below the surface of the land as not to interfere with superficial ploughings; but when the plough is made to penetrate more deeply, they impede its action: these stones must, therefore, be removed before the land can be properly tilled. Occasionally, immense masses of stone will be found to exist in the soil, which only appear, at the surface, to be mere pebbles, and are thus supposed by casual observers to be of trifling import. These cannot be dug out without considerable labour and expense, which can only be repaid, or in any measure remunerated, in those places where the stone thus extracted from the ground can be advantageously used or sold: consequently, this circumstance ought to receive due consideration, when it is proposed to plough such land to a greater depth, and to make use of improved implements.

Those loose stones which give way before the plough and harrow, are exceedingly prejudicial to agriculture, when they exist in too great numbers in a soil. They do not yield any nourishment to plants, and, therefore, may be reckoned as worse than nothing in the layer of vegetable mould of which they form a part. They are also prejudicial in consequence of the injury which they cause to the agricultural implements, in their impeding the action of the scythe, and compelling the reapers to leave the stubble very long. Therefore, whenever the agriculturist wishes to introduce a system of improved cultivation, he must endeavour to get rid of all these stones by having them picked up, or otherwise separated from the soil: this can, however, seldom be effected without considerable expense. Some persons have considered that it injured a soil to deprive it of these stones, and allege, in support of their opinion, that the office of the stones is to refresh the soil, and communicate heat to it as may be required; that they protect the seed, and have a tendency to retain moisture: but these assertions will not bear the test of inquiry. With respect to those experiments which are brought forward with a view of supporting this theory, there are so many facts and observations of a diametrically opposite nature, and which are well attested, that we cannot give to the former the slightest credence. We do not, however, mean to deny the utility of lime stones in argillaceous soils, because the manure with which they come in contact, as well as the touch of the roots of the plants, gradually decompose them, thus ameliorating the soil, and affording additional nutriment to vegetables; but where the stones are of a silicious nature, as is too often the case, we must beg leave to deny their utility, at least until some positive experiments shall convince us of the contrary.

In describing the general surface of an estate, or drawing out an exact plan or description of a certain extent of land, founded both on the composition and on the constituent parts of which the soil is composed, and which may serve to guide us, not only in estimating the land, but also in choosing the proper system of cultivation for it, and the rotation for which it is best adapted, it is absolutely necessary to pursue some regular and systematic course of proceeding. If the land is not already divided into beds or portions which form a species of distribution of it, parallel lines must be traced upon it, about five, ten, or fifteen perches apart, according as the nature of the soil undergoes a greater or less change.

At the same time, a plan of the piece of land which is to be estimated should be drawn out on a tolerably large scale; that is to say, nearly four times the size of ordinary territorial plans. The parallel lines above mentioned must be traced on this plan, and intersected or divided into portions of from five to ten perches each: these portions should be numbered in rotation. Besides the men who measure the land, there must be two others, one with a spade to dig up, and the other with a basket into which to receive the samples of soils that are raised. The surveyor sketches the plan or chart, and draws up the reference book, unless some other person is employed expressly for the latter purpose. The agriculturist observes the nature of the soil, and directs the whole operation. As soon as he perceives any change, he stops, and desires that this spot may be marked on the plan, and then enters into a more accurate examination of the alteration: should it appear to him to be necessary so to do, he causes some of the earth to be turned up with the spade; and if he considers that a yet closer analysis will be beneficial, he places about a pound of the earth in a horn or little bag, on which he marks the number or letter of the station. The places where these variations in the nature of the soil occur, must be marked out on the plan, by the surveyor, with all possible precision; neither must he omit to signify whether this change takes place at once, or comes on gradually. Whatever other remarks are considered necessary, as those which relate to the properties of the soil, or the changes produced in them by the alteration, &c., should be inscribed in the reference book, under the number appertaining to the portion of land in which they occur.

In this manner the whole of the land is passed over in the direction of those parallel lines which were traced upon it, and thus, in the course of this operation, a draught of a geometrical plan is formed.

With regard to the plan itself, it may be drawn out in various ways; but the best mode of proceeding is to designate the various component parts of which the soil is composed by water colours, and indicate the almost insensible changes of composition by shades of colour. The heights and hollows may be signified by what is called "ground-lines," properly shaded; the greater or less quantity of humus with which the soil is impregnated by black dots, which must be placed nearer to one another the more humus there is in the soil: thus all points worthy of notice will have their distinctive signs. With such a plan, the agriculturist will always have an exact picture of his land before his eyes, and can therefore make those arrangements which he thinks will be most suitable to the nature of its different parts.

It is not impracticable likewise to trace out on this plan the direction of the declivities and water courses, &c.; but if is deemed necessary to have all these things indicated in a more detailed manner, the levels and heights must all be measured with instruments proper for the purpose. These levels may be taken in different directions, and then the mere vertical profile is given. If the substratum of the soil undergoes any change, and it is thought necessary to analyze and make special mention of it, that may very easily be done by shadowing the profile of the plan or chart with colours which shall indicate the thickness of the various layers. In this case the auger or land-sound may be used in taking the level, and introduced into the soil as deeply and as often as is necessary. This can be done without any great difficulty.

Where the constituent parts of a soil cannot be distinguished with sufficient accuracy by means of its external characteristics, or where it is otherwise deemed expedient to submit it to a more minute examination, it must undergo a chemical analysis. But if the samples which have been taken from different spots are compared together, both in a state of moisture and of desiccation, it will generally soon become evident which are those that are of an homogeneous and also those that are of a different nature, without the necessity of having recourse to chemical analysis.

No operation will so fully compensate an enlightened agriculturist for the trouble which it costs him as this mode of proceeding; he will here find a solution of all those phenomena which previously appeared inexplicable, and will thus be enabled to apply an efficacious remedy to the various impediments and inconveniences which he may meet with in the cultivation of his property.

## SECTION IV.

# AGRICULTURE.

The term "agriculture," considered in its strictest sense, signifies the tilling and preparing the soil, and rendering it capable of producing those crops which are required from it in their highest state of perfection.

This effect is produced in two ways: the first, which is designated "chemical agriculture," or in other words, and in common language, the "amelioration of the soil," consists in adding to it all those substances which tend to increase its fertility, by incorporating nutritive matter and juices with it, or developing and calling into action those which it already contains; the second, which is called "mechanical agriculture," or the "cultivation and tillage of the soil," consists in loosening the earth by means of ploughing or digging, or otherwise working it, so as to enable the roots of plants to penetrate it without difficulty, and seek and appropriate to themselves those substances which are most analogous to their nature.

We shall enter fully into these two subjects or divisions in the course of the present chapter.

### PART I.—ON MANURING AND AMELIORATING THE SOIL.

Manure acts upon the soil in two ways:—

First, by communicating to it those juices which are calculated for the nutrition of plants and vegetables:

Secondly, by the chemical action which it exercises on those substances contained in the soil, decomposing them, and recombining them under new forms, and thus facilitating their introduction into the suckers of plants; and, perhaps, also by communicating that degree of energy and activity to vegetation which enables it to take up and appropriate the suitable nutritive juices.

Some kinds of manure appear to produce only one of these effects, or at least to produce one in a far greater degree than the other; while others, on the contrary, seem to produce both.

We generally express the effect of manures on a soil by saying, that they fertilize it, and many persons would be satisfied with this expression; nevertheless it is exceedingly necessary, both for the sake of theory and practice, that we should endeavour to define the way in which each variety of manure produces its peculiar effect, and under what circumstances it acts in one way rather than in another. It is only by means of such knowledge that we are enabled to account for various facts which are to all appearance contradictory; and can learn to make a prudent selection among all the various proceedings which are to be followed in the use of any one particular kind of manure.

The English have instituted a very good comparison when they compare manures belonging to the first class to food, and those appertaining to the second class to salt, spices, or stimulating drinks.

All organic substances which have entered into a state of putrefaction or decomposition, contain the elements necessary for the reproduction and perfecting of the vegetables which we cultivate. If, by means of seeds or roots, we bring the germs of some particular plant in contact with these substances, and all the other details appertaining to the operation are properly conducted, plants of a similar species to that which we set will be produced. All soils contain the aliments proper for every kind of plant, but not in equal proportions; that is to say, every soil does not contain similar proportions of alimentary substances. In fact, it is well known that some kinds of land favour the vegetation of one plant, while others are peculiarly adapted to a totally different kind.

Vegetable decomposition, or manure appear to act on plants solely as an aliment; it does not seem to contribute much towards the development of those parts which the soil already contains, and which are formed of the residue of previous manurings, now become insoluble from the action of various causes. Animal decomposition or manure, on the contrary, acts on the soil as well as on the plants which vegetate there. It not only contains all those substances which are indispensable to the vegetation of plants, some of which, certainly, are contained in vegetable manure, although in smaller proportions; but it also favours the decomposition of the insoluble humus, and communicates a greater degree of energy to the vegetation of plants.

Mineral manures which do not contain any organic bodies act solely, or at least essentially, by improving the texture of the soil, rendering those parts of it soluble which were previously insoluble, and favouring and accelerating decomposition.

Every organic body is formed by the combination of three, four, or more elementary substances united by vital power in certain determinate proportions; but when the vital principle ceases to exist and to act upon them, those combinations are resolved into their original elements, and again submitted, either wholly or in part, to the organic laws which govern those elementary bodies. These latter subsequently unite, either in the form of simple combinations, that is to say, two and two, according to the laws of affinity, or in more compound combinations of an entirely new character. These latter, without appertaining to life, owe their existence to it, and in their turn assist in supporting the vital principle. Vegetables derive their chief nutriment from the combinations resulting from the decomposition of animal and vegetable life, and in the natural course of things become, in their turn, the food of men and beasts.

These newly-formed matters, viz., the more or less decomposed manure and the humus which arises from it, vary in their nature according to the different substances from which they were derived, and the circumstances which influenced their formation.

The progress of their transformation is designated by the terms "decomposition," "fermentation," and "putrefaction." We shall not enter into a definition of these terms, but content ourselves with making the following remarks:—

The conditions of the state which we designate by these words are, total absence of vitality, *heat*, *moisture*, and a *species of combination with the atmosphere.* According as these concomitant circumstances increase or diminish in intensity, this process will undergo various modifications, be accelerated or retarded, and be attended with different results.

Vegetable bodies pass through various degrees of fermentation before arriving at the last of them, viz., putrefaction, and becoming entirely decomposed or reduced to a state of mould or manure; a state which ought not to be regarded as permanent and unalterable, but merely as having some duration.

Animal bodies, on the contrary, pass over the first degrees of fermentation altogether; or, at any rate, are but so very slightly affected by them that they are scarcely perceptible. These substances enter at once into a state of putrefaction, and cause all vegetable bodies with which they are in contact to do the same.

This putrefaction and the matters which result from it also experience various modifications, which are dependant on the strength of the combinations taking place in them, and the intensity with which heat, moisture, and atmospheric air acts upon them.

In the open air, and without the intervention of moisture or of any additional heat, the process of fermentation and putrefaction is not perceptible; a species of decomposition does, however, take place, which is similar to slow combustion. This decomposition produces a very different matter to that which is the result of putrefaction, and one which is smaller in quantity, because the greater, part of the carbon combines with oxygen, and evaporates under the form of carbonic acid.

The greater degree of rapidity with which animal bodies are decomposed by putrefaction, doubtless arises from these bodies being but slightly complicated in their nature, from their being composed of an infinite variety of substances, and, among others, of those numerous vegetable preparations which enter into the food of animated beings. The product of this putrefaction is different; it has a more energetic effect on plants, because it acts not only as an aliment, but also as a stimulant; and this will account for the fact of its being very rapidly and easily exhausted. The dung of animals is a very active, but far from being a durable manure.

All animal bodies, as dead carcasses, flesh, intestines, the refuse of the shambles, &c., when in a state of putrefaction may be converted into manure; and those manures which are thus formed are far more active than any others. These substances may be employed for this purpose; but in general the excrements and urine of animals obtained from them during life are set aside for manure, because a large quantity can thus be obtained and at a much less expensive rate.

It is found to be very advantageous to mix these excrementitious substances with the remains of vegetable matters: by which means the latter are led to enter into a more rapid state of putrefaction, and do not lose so much of their actual substance; while the fermentation of the animal bodies, which would otherwise be carried on with too great rapidity, is somewhat retarded. Manures thus formed are called "natural manures," in order to distinguish them from others which are termed "artificial." This appellation is not, however, bestowed because they are more simple than others, or because they require less care and skill to be bestowed on the preparation of them, but merely because they are the best known, and, indeed, among many persons are the only kind of manure which is known and used.

Those excrements which are voided by animals through the intestinal canal, are composed not only of the residue of the food which they have taken and of that portion of its filaments which could not be decomposed, but also of molecules of the body of the animal itself, which are deposited in the intestinal canal after having performed their office; consequently, these excrements may be said to be entirely composed of animalized substances, and even in animals fed almost entirely on vegetables will be found to possess more of the animal than the vegetable nature. The properties of the dung, however, depend to a certain extent on the manner in which the beasts are fed, and their condition and breed. If the animals are so fed that their stomachs contain a very small portion of nutritive juices, but an immense quantity of fibrous matter which is not easily digested or decomposed, as, for example, straw, and the dried stems of plants without any admixture of grass or corn; these substances will pass away from the intestinal canal almost in the same state in which they entered it, and become less animalized in proportion as the lean and ill-conditioned body of the animal parts with less of the fleshy particles. But even the small admixture of animal matter thus obtained suffices to give these excrements a greater and more rapid tendency for entering into a state of decomposition or putrefaction. But the excrementitial matter voided by animals which have been brought into good condition by nourishing food full of gluten, farina, albumen, mucilage, and the saccharine principle, and in which a large number of molecules are daily reproduced and detached; the excrements of such animals, I say, furnish an infinitely more active manure, and one which contains a much smaller proportion of vegetable and fibrous parts. Hence arises the striking difference which exists between the dung yielded by cattle put up to fatten, or which are in good condition, and that which is voided by lean, badly-fed animals. A proportionately greater quantity of litter may be added to the former without impeding or retarding that uniform fermentation which leads to putrefaction.

It is generally customary to mix urine with the solid excrements. This liquid, which is in fact composed chiefly of water, likewise contains a substance which is peculiar to itself, and various other very active matters, and several phosphates, but particularly the phosphate of ammonia. By evaporating urine it has been found that not only the liquid itself, but those salts also which are obtained from it in small quantities are very favourable to vegetation. But Dr. Belcher, in his "Communications to the Board of Agriculture," says that plants may easily be too highly stimulated and even destroyed by the action of this fluid. He attributes this effect partly to a small yellow insect frequently met with in urine. Numerous experiments seem to prove that the various matters contained in this fluid are most efficacious when mixed up with the solid excrements and collected by means of the litter, or of certain substances peculiarly adapted for the purpose; these substances having a strong tendency to decompose one another, give rise to the formation of new compounds.

Common manure is composed of these two kinds of excrements and of those vegetable substances which are used as litter, as straw, fern, or dry leaves, but chiefly the first of these three; this mixture is commonly termed stable-manure, a name by which we shall henceforth designate it.

Stable-manure varies in quality according to the kind of animals by which it is produced, even where these animals have received the same kind of food and of pasturage.

Only a few of these varieties of dung have been decomposed and accurately analyzed. The dung of horned cattle has been analyzed by Einhoff and myself; it will, however, be necessary to conduct the analysis with greater accuracy and with the aid of a pneumatic apparatus before we shall be able to institute an exact comparison between the different kinds of dung and their component parts.

Among the numerous phenomena exhibited by stable-manure, we shall only notice those which are easily observable, and which serve to distinguish the various species from one another.

When horse-dung, in a proper state of humidity, is exposed to air of a moderate temperature, it soon enters into fermentation. So great a degree of heat is engendered by this process, that the moisture and all the volatile matters are expelled, and, if the dung is not watered, instead of assuming the form of a thick paste or black-butter, as it is commonly called, it becomes friable, pulverulent, and wastes away, so as to leave scarcely anything but ashes behind; when it has not been pressed together, but is so loose that the atmospheric air can penetrate into its substance, it decomposes unequally, becomes partially carbonized like turf, and covered with a considerable quantity of mould, which, experience has repeatedly shown, greatly impairs its manuring qualities. It is of a much more fertilizing nature when produced by vigorous animals which consume a considerable portion of corn, than it is when produced by such as are fed with nothing but grass, hay, or straw; but even in the latter case it is still valuable as a manure. When manure of this kind is laid on the ground before its decomposition is completely effected, it produces a very rapid effect, and greatly accelerates the growth of plants through the heat which is developed in the ground after the dung has been buried there. This circumstance renders manure composed of horse-dung peculiarly beneficial to moist, cold, sterile, clayey soils, the faults of which it corrects, while at the same time the soil checks the too violent action of the manure. On the other hand, this kind of manure is often exceedingly injurious to soils of a dry, chalky, sandy, or calcareous nature; it there accelerates and stimulates the growth of the plants in the early stages of their development so much, that when the action ceases the process of vegetation becomes feeble and languid. The effects of such manure are also very transient, because it becomes consumed by the very energy of its own fermentation, and leaves but a very trifling residue. The only soils in which this does not take place, or in which the effects of manure composed chiefly of horse-dung are at all durable, are in those of a moist and tenacious nature. Manure of this description is exceedingly beneficial to soils which contain a large quantity of insoluble humus or vegetable mould, because the ammonia which it contains greatly facilitates the decomposition of this substance.

If the dung has reached that stage in which fermentation, accompanied by rise of temperature, or the disengagement of heat is at an end, it still leaves a residue highly favourable to vegetation in all the soils with which it is incorporated; but this residue is very small in quantity.

When the dung is to be used by itself, it must be carried to moist and clayey soils as soon as its first stage of fermentation has commenced, an effect which soon takes place, and there buried. It ameliorates the land by its mechanical action, rendering the soil looser and lighter by its continual fermentation and the heat which it engenders; besides the repeated ploughings which are requisite, in order that it may be thoroughly mixed and combined with the soil, contribute materially towards the goodness of the crops sown on that land.

But when it is to be used upon warm, light soils, the most advantageous mode of employing it is to mix it with vegetable substances which still retain their succulency, or with earth, and especially with turf. For this purpose the dung should be mixed with the substances just mentioned, and heaped up in successive layers, care being taken to protect it from too free an access of air, and to moisten it whenever the weather is too dry. By this course of proceeding a very active compound will be obtained, which is permanent in its effects and exceedingly well adapted for light soils.

Stable-manure produced by horned cattle also begins to ferment very soon, provided that it is close and uniform in consistence, and contains only its own proper moisture; but its fermentation is less rapid, and developes less heat than that of horse-dung, consequently the moisture of this kind of manure does not evaporate anything like so rapidly, and it does not require watering, neither does it fall to powder, but rather assumes the form of a tolerably consistent paste, which is commonly called black-butter. So long as it is kept in a compact heap there is no danger of its being rendered pulverulent by desiccation; and when its moisture is entirely evaporated it presents the appearance of turf, and almost that of coal. Its specific gravity is greater than that of water, both when it is fresh, provided that it has not been mixed with straw, and also when it has undergone decomposition, and the tubular stems of the straw have been converted into filaments.

Its effect on land is less rapid than that of horse-dung, but proportionately more lasting. The different kinds of crops, too, for which it may be used, are more numerous and more various in their nature. When this manure has not been very carefully and minutely divided, it is found in the soil in a turfy form, and in lumps of greater or less magnitude two or three years after it has been placed in the ground. When placed in the soil, it does not appear to produce any very sensible increase of temperature, and for this reason it is peculiarly and, we may say, exclusively adapted for the manuring of warm soils. It has been and is commonly said that cow-dung cools soils of the latter description: a more correct mode of expression would be to say, that it does not heat them. When buried under the layer of vegetable mould in tenacious and clayey soils, it will probably not appear to produce any effect, at least until it is brought into contact with the air by repeated ploughings. When buried in an early stage of its decomposition, the tubes of the straw with which it is combined serve to keep up a communication between the dung and the air, and thus its decomposition appears to be accelerated. Straw which has not been bruised, and the tubes of which are entire, also produces a beneficial effect on these soils.

Sheep-dung when kept in a compact heap, and retaining its own moisture, decomposes rapidly; but where it is loosely heaped and its moisture has the means of escaping, the process of decomposition is effected slowly and with difficulty. When plcaed in the soil or voided over it, it seems to exhaust itself very rapidly, and produces a speedy and energetic effect. When used abundantly it often gives too much vigour to the first crop, and accelerates vegetation in too great a degree; it should, therefore, be used upon the land in smaller quantities, both as regards weight and volume, than any of the other kinds of manure. In most cases its action does not extend beyond the second crop.

The excrements, and especially the urine of sheep, disengage an immense quantity of ammonia. This circumstance makes the use of sheep dung very advantageous, especially on soils which contain insoluble humus or vegetable mould.

The dung obtained from sheep-folds is generally of two kinds. That which forms the upper stratum is brittle, dry, and undecomposed: that which forms the lower stratum, on the contrary, is solid, moist, and adhesive. Unless great care has been taken to stir it up, so as to form it into an homogeneous mass, it must not, on any account, be spread indiscriminately over the same field. The dry portions of it produce very injurious effects, on elevated lands of a warm, dry nature; but are more beneficial on moist soils, particularly if they are slightly sour or acid. A large quantity of this dry sheep dung may be spread over soils of the latter description, without occasioning any inconveniences; but the decomposed portion, or under stratum, must, on the contrary, be spread but very thinly over any kind of land, otherwise it tends to lay the corn.

Opinions are much divided with respect to the qualities of pigs' dung mixed with straw. Some authors speak of it as being very energetic in its action, while others attribute but very trifling effects to it. The qualities of the dung yielded by all animals, are greatly influenced by the kind of food which they consume; but this fact is more perceptible in the dung of pigs than in that of any other kind of animal. It is not a matter of indifference, either as regards the quantity or quality of the dung, whether it is produced from swine that are poorly fed, or from such as live upon rich food. The quality of the dung also depends, in a great measure, upon the methods resorted to for the purpose of collecting it. If care be taken to keep the straw of the litter dry, by providing some means of carrying off the urine rapidly, either by letting it run through holes made in the floor, or else carrying it off by means of gutters, &c., the straw retains but a small portion of animal matter, and is capable of producing but little more effect than that of ordinary rotten straw. But if, on the contrary, the liquid portion of the excrements are mixed with the straw in such a manner as that there shall be no possibility of their running off, and the dung is placed in a situation which is favourable to its decomposition, a very active compound is produced, which, after having undergone its first fermentation, is entirely freed from that acrid quality which the dung of swine is said to possess.

In most farming establishments the quantity of dung produced by poultry is but small; but, on the other hand, this dung is very active and of great value. It is very different from that of quadrupeds, and contains a peculiar substance which seems to be mainly composed of albumen. We possess an exact analysis of this kind of manure made by Vauquelin. This chemist discovered a marked difference between the dung of cocks and that of breeding hens; a difference which does not extend to hens which do not lay eggs. Poultry dung, although used in small quantities, exerts a surprising effect, provided that special care is taken to divide it minutely; but this effect is much less sensible where the dung is placed in the ground in large lumps.

In order to make manure derived from this dung useful, it is necessary to divide it as minutely as possible, and spread it over the ground without burying or covering it up.

Human excrements, or nightsoil, are known to make a very active manure; they differ essentially in composition from those of all domesticated animals. Their own quality probably varies according to the food from which they are produced. It is an undeniable fact that the excrements voided by human beings who live chiefly on animal food, are much more active and efficient as manure, than those which proceed from persons whose diet is principally composed of vegetables.

Those who know how to turn these fœcal matters to the greatest possible account, and can surmount the disgust which the use of them occasions, prefer them to all other kinds of manure. It has been asserted that the excrements of a man are capable of producing a quantity of vegetable matter sufficient for his own support, but it is easy to see that this assertion is greatly exaggerated. There is, however, no doubt that if these excrements were carefully collected, and turned to the greatest possible account, the quantity of aliment obtained from their use would be so great, that Europe would be capable of supporting another population of human beings. At present, they are generally left to decompose, without being turned to any account; or are carried off, by drains, to large rivers, and thus to the sea.

The disgust occasioned by the use of nightsoil arises, in part, from the offensive smell which it, at first, gives out, and from a prejudice to which this disgust has given rise; viz., that manure thus formed communicates an unpleasant flavour to the plants which are nourished by them. Another cause of objection arises from most persons being unacquainted with the proper manner of using this kind of manure, to which cause most of the bad effects which it produces may be attributed; at all events, it does not yield benefits proportionate to the trouble which it occasions.

Nightsoil produces surprising effects when carried to the land before its fermentation is completed and spread over it with care. The best way of using it is to form it into a kind of compost, by mixing it with other substances, and especially by making it into heaps with turf, and adding a small quantity of burnt lime. By this means the superfluous energies are reduced to the requisite standard, and the effect extended over a greater space, without, however, there being any danger of the energy of the active matters which it contains being lost or impaired by this diffusion. This manure then loses its fœtid odour, and becomes divided and mixed up with the other substances and forms a fertile soil. The best way of using it is to spread it over the ground without covering or burying it. It should be mixed up several times, and all the substances thoroughly mingled together before it is used.

When nightsoil is spread over the heaps in which the dung of various kinds of cattle is collected, as is generally the case in places where these matters are not altogether thrown away, it does not produce anything like that effect which might be expected from it if it were more divided.

Large quantities of nightsoil may be obtained in towns; sometimes it may even be obtained gratis, but even then the carriage of it renders it expensive. In the country, in farms and villages, it is always advantageous to prevent the loss and evaporation of this matter; for this purpose it should be collected in privies, whence it may be taken when required, and mixed up with earth dug from ditches and a small quantity of quicklime. This mode of proceeding prevents the disgust which would be occasioned by seeing human excrements lying about the buildings and hedges.

In the neighbourhood of Paris there is a large establishment in which a very active manure is manufactured from nightsoil. It is made in the form of powder, and for that reason is called *poudrette*. The excrementitial matter is placed on an inclined plane covered with stone slabs, and there made into heaps in order that it may ferment, and when dry is spread out over a greater extent of surface: a harrow is then passed over it to break it up; it is subsequently placed under cover, where it is frequently heated afresh and thoroughly dried. It is then reduced to powder, which resembles brown tobacco in appearance, and sold to farmers, and particularly to gardeners, who, to judge from the price which they pay for it, certainly must derive immense benefit from the use of it.

The inhabitants of Belgium also make great use of this kind of manure. They import and procure it from considerable distances even in the form of a paste, and go to fetch it in carts and boats without caring for the offensive odour which it exhales. They either use it in the form of compost, or mix it with a large quantity of water. It is highly valued in China and Japan, and hence has been called "Japan manure."

We now return to the processes connected with stable manure, the largest and most important part of which is furnished by the horned cattle.

The dung of horned cattle is usually collected by mixing it with straw. Even though it might be advisable to depart from this method for the sake of having the cattle more warmly lodged, and providing them with more comfortable beds, even if this method should not be attended with the greatest possible convenience, it is nevertheless to be preferred, because the mixture accelerates the decomposition of the straw, prevents the evaporation of the dung and its volatile ingredients, and therefore contributes to increase its goodness. The tubes of the straw in particular absorb the liquid portions of the urine, which there deposit their most active and efficient parts.

There are a great many different methods of storing up, and preserving this kind of dung. Some persons keep it for a considerable period in the cow-house, covering it every now and then with a fresh layer of straw; it thus accumulates to a considerable height, so that the cattle are soon raised above the rack. To obviate this inconvenience, moveable cribs are made which can be raised at pleasure. This method is resorted to merely for convenience sake; it avoids the necessity of clearing out the dung as often as would otherwise be necessary, enabling the farmer to cart it all at once, and thus saves trouble. It is thought too, that the quality of the manure is improved by this method. The process of decomposition is commenced by the action of the moisture naturally contained in the dung, and as it is then less exposed to the atmospheric air, it loses little or nothing by evaporation; it even absorbs the dense vapours which exhale from the cattle and collect near the ground. These facts are indisputable, and the fear entertained by some persons that the vaporous exhalations arising from the dung may be injurious to the animals, is quite as groundless. There is no offensive smell observable in the stables; the air contained in them is always perfectly pure and respirable provided that they are properly ventilated; which, by the way, is generally the case. The manure thus obtained, especially that which constitutes the lower stratum, is of an excellent quality; and by the time that it is removed from the cow-house it has passed that stage of fermentation in which it evaporates most quickly, its volatile parts having already entered into combination with the solid matter.

But this method cannot well be employed when the cattle are supplied with a considerable quantity of food composed chiefly of succulent and juicy vegetables, unless they are allowed an enormous quantity of straw for litter; for the amount of dung produced by cattle receiving this kind of food is so great, that its moisture cannot be properly absorbed by the litter, and consequently the cattle sink into it, and are always standing in a slough.

In order to realize all the advantages attendant on keeping the dung in the stable, and at the same time to avoid the inconveniences just mentioned, the mode of constructing stables or cow-houses mentioned by Schwertz in the second volume of his "Agriculture of Belgium," is certainly very convenient. By the side of the space assigned to the cattle, and behind them, is a space at least as broad as that which they occupy, but a little lower; it is in this space that the dung is deposited as it is removed from under the cattle. It is here, too, that the urine and the moisture of the stables collect. In the same place the dung usually undergoes decomposition, and thence it is carried directly to the fields which it is destined to manure. Were it not that in the greater number of agricultural establishments the adoption of this method is prevented by the expense which the erection of such buildings would entail, an expense which would be double that of those which are in common use, this method would decidedly merit the preference over all others, and would be worthy of universal adoption. If the stables are sufficiently large to admit of the dung being left in heaps behind the cattle for a week or a fortnight, this must be looked upon as a great advantage, because by that time the dung will have passed that stage of fermentation in which its evaporation goes on with the greatest rapidity.

The dung should, therefore, be left in the stable as long as possible, because the longer it remains there, the more it is improved in quality. But this consideration ought always to be regarded as subordinate to the imperious necessity of keeping the cattle in a proper state of cleanliness, and the stable dry. If the animals are allowed to stand in a state of filth, much more will be lost by the diseases entailed upon them than can possibly be gained by the increased value of the manure. Damp stables or cow-houses engender serious swellings and inflammation in the thighs, which we know, from experience, often turn out fatally. It is also a well attested fact, that when cows are badly housed and not properly littered, their milk becomes bad.

If the dung is suffered to remain under the cattle, great care must be taken that it does not collect in larger quantities under their hind, than under their fore-feet, because, in such a case, the animals will be placed in an attitude which is altogether contrary to their nature. This inconvenience is the more likely to happen because the excrements fall behind the cattle, and, consequently, the cow-herd strews a greater quantity of straw there in order to cover them. Hence, then, it is very evident that it is only when the cattle are fed on dry food that it is possible to leave the whole of the dung under them; unless, indeed, the stable is floored with planks, and has beneath it a hollow space into which the water can run through the interstices of the boards. This last-named method is pursued in countries in which the dung is of but trifling value, and where, consequently, but little importance is attached to it.

But the practice usually adopted is to carry the manure at once from the stables to places destined for its reception, where it is allowed to remain for a certain period in heaps of various sizes, previously to its being carried to the land which is to be manured.

These receptacles for manure are arranged in various ways. Sometimes they are large excavations, and then they form actual dung-pits. This form is positively injurious, not only because the moisture which collects in these pits checks the fermentation and decomposition of the manure, but also because the manure is too much shut out from contact with the atmosphere.* Besides, this arrangement renders the carting off of the dung an operation of much greater difficulty, the manure frequently being so saturated with moisture that its most fertilizing parts ooze away drop by drop as it goes along the road. Indeed, the inconveniences attending these dung-pits are so great and manifest that they are rarely used as receptacles for the dung of horned cattle, excepting in places where there is not sufficient space to allow of the manure being spread out and made into heaps.

Some persons, aware of the disadvantages attendant on a very damp situation, have recourse to the opposite extreme, and lay their dung on a flat or even on an elevated surface; but in such situations it loses too much of its moisture, and becomes deprived of its most active ingredients by evaporation.

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* So far from considering it any disadvantage to keep the dung shut up, at least to a certain degree, from all contact with the atmospheric air, I am rather inclined to recommend such a course of proceeding; provided that at the same time a quantity of urine and water be left in it sufficient to favour its fermentation and decomposition, but not so great as to retard either of these processes.

The most advantageous arrangement seems to be to have the place in which the dung is to be kept slightly hollowed out. There should be a trifling inclination on one side towards the centre, and at the bottom of this an opening through which the superfluous fluid may escape into a basin or reservoir prepared for its reception.* The whole should be surrounded with a raised border to prevent the admixture of moisture from other sources. Where the influx of extraneous water or fluid can be entirely prevented, the humidity of the dung will rarely become too great, even if the whole quantity of urine running from the stable or cow-house is mixed with it, provided that the cattle do not live upon very watery food, such, for example, as the residue of the distillation of brandy from grain. Dung absorbs the natural moisture of the excrements as well as that which falls immediately from the atmosphere, and, by the heat which it disengages, causes the superfluous portions to evaporate. I am convinced that the best way of turning the urine to account, is to incorporate it with the mixed dung and litter. The amount of liquid which on this plan will run from the heap, is inconsiderable, excepting in very wet weather, when it will be collected in the reservoir provided for that purpose; and, if the dung heap is laid on a slope, no further arrangement is necessary, as the moisture will drain through it quite sufficiently.

It has been proposed to construct roofs over the dung-heaps, which in some instances have been carried into effect. These roofs are intended not only to defend them from the rain, but also from the rays of the sun; but they present considerable difficulties where the dung-heap is large; and it is impossible to protect the loads of manure, as they are brought from the stables, particularly as the same load should consist of a portion from several stables.*

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* The pits intended to receive the urine and other liquids proceeding from manure, are commonly termed *fosses à lizée*, and the fluids thus contained are distinguished by the name of *lizée*.—FRENCH TRANS.

The dung heap should be placed at one extremity of the stable, and with room only for a loaded waggon to pass between. The road to it should be paved, and slightly elevated, to prevent the water that falls from the roof of the stable from running into the dung-pit; this water should, therefore, be carried off in a different direction. Covered drains should pass under the road, to convey from the stable into the manure, the waste urine that has not been absorbed by the litter.

If the dung is not carted till it attains an advanced degree of decomposition, it is necessary that the receptacle for it should be divided into several compartments; that each should be filled and emptied in its turn: or, otherwise, fresh dung would have to be carted with that which was rotten, or much time would be lost in separating them.

Sometimes separate places are appropriated for the reception of different species of manure, particularly that from horses and pigs, and sometimes the different sorts of manure are all united in one place. When the soil varies much in quality, and there is sufficient space, it would be well to separate the manure heaps, and to devote each separate heap to that part of the land, to which, as we have before shown, the manure would be most appropriate. Horse dung should be deposited in a pit, or narrow deep ditch, not only to preserve the moisture, and to keep it cool, but also that it should be more condensed, and less exposed to the atmosphere. By this means, its fermentation and putrefaction will be rendered slower; and the mass will be more compact, particularly if from time to time care is taken to water it;, and if it is wished still further to retard the fermentation, it will be well to mingle with it the dung and urine from hogs. In this manner the manure from these latter animals, which is cold, and not readily fermented, becomes quickly decomposed; and the mixture of the two will form a very valuable compost.

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* Most persons who recommend new methods to be employed in agriculture or rural affairs, generally content themselves by considering the effects, without comparing them with the expense at which they are to be produced. In this case, it is very doubtful whether the expense of such a construction, and the annual charge to keep it in repair, considering the constant exposure to the hot vapours arising from the dung, would not more than counterbalance any advantages to be derived from it.—FRENCH TRANS.

In ordinary circumstances it is more convenient to mingle the different species of dung uniformly in the heap, so that the defects of one sort of manure may correct those of another; and the result will be a regular and well-digested compound. It is a general custom to keep the manure from sheep separate; and in many rural districts the sheep-fold is separated from the other buildings, and the dung is left under the animals all the winter, taking care to cover it with fresh straw, that they may lay dry. The removal of the dung of sheep during winter causes great inconvenience, even when the sheep leave the fold during the day, for when the dung is accumulated and removed, it exhales strong ammoniacal vapors, which much disturbs the sheep when they return to the fold.

However, if it can be so arranged as to avoid these inconveniences, much benefit will be derived from mingling the dung of sheep with that of other animals; and all who do so, are sensible of the advantage.

The experiments which I have tried, and published in the first volume of "*L'Archive d'Humbstadt,*" and the observations that I have since made on the subject, have fully convinced me, that manure acquires more strength, and diminishes less in bulk, when it is protected as much as possible from the atmosphere during fermentation, and till it has developed the greater portion of the volatile parts. I think, therefore, that covering it with earth, where it does not cause too much labour, is useful; but, as it is always attended with inconvenience, it will be found sufficient to spread the manure evenly, on a surface, proportioned to the quantity to be deposited. As long as the fresh manure remains at the surface of the heap it does not sensibly ferment, and it prevents the portion beneath from coming too much in contact with the atmosphere; the gases which disengage themselves, with the exception of the ammonia, which in such a situation is but slightly developed, are heavier than atmospheric air; they, therefore, remain above in the upper layer of the heap, which prevents their being lost: and it is very probable that they are again absorbed and form new combinations. There is no sensible smell from a dung-heap thus constructed. Air collected immediately above the heap has hardly any effect on lime water, nor does the application of nitric acid discover any ammoniacal vapours; it is only on the turning over the manure that these effects are produced. This proves, that whilst removing, much carbonic acid, azote, and hydrogen gas is disengaged; but that whilst it remains stationary, and partly protected from the atmosphere, these gases, instead of being evaporated, merely enter into new combinations.

It is of great consequence that the dung should be equally spread over the whole surface, and not thrown on in separate heaps; for between these heaps there will always be vacant places, which will soon engender mould, which much deteriorates the quality of the manure. Manure thus deposited is much improved by being condensed; it is, therefore, a good plan to surround the heap with a balustrade, so that the cattle can be driven over it. I am aware, that some authors consider this practice as detrimental; but I cannot agree in their opinion, having, from a place where several carts passed every day over the heap, obtained manure of the very best quality, and perfectly decomposed. When the dunghill has arrived at a height of five or six feet, it is well to cover it with a coating of earth or turf, which will absorb the vapours as they rise; and when the manure is carted, the turf, which is not entirely decomposed, should be placed at the bottom of the pit, when it will become a very rich soil.

To prevent the loss of any of the liquid parts of the manure, it has been recommended to have the floor of the dung-heap paved, or even cemented, that they may not filter into the earth. If the soil is clayey, this is perfectly unnecessary. In constructing a new receptacle for manure on a sandy soil, it may be of service; but in an old place where the earth has once become saturated, it will not imbibe more; even on a sandy soil I have found, on removing a dung-heap situated on white sand, that for the depth of about one foot the sand had become perfectly black, but below it the separation was complete, and the sand remained pure and white.

After having removed one heap, and when commencing a new one, such vegetable substances as are most difficult of decomposition should be placed below, such as the leaves of trees, weeds, the stalks of plants, in short anything that will best absorb the juices from the dung, and which after putrefaction will form good manure. In Switzerland, where great care is given to all the manipulations, dung made from straw litter is put in regular heaps, whilst the urine, after being collected as it issues from the stable in a trench provided for the purpose, is used separately. They form the outside of the heap of the most strawy part of the dung, and for this purpose they fold it with a fork in such a way that the dung is shut off from contact with the atmosphere. These dung-hills are elevated five or six feet, and arranged with the greatest care, so as to have the appearance of straw hives; because, on the outside nothing is seen but the folded straw, which is arranged with the most perfect uniformity. In dry weather they water these heaps, or pour over them the liquid from manure, in order that they may be kept sufficiently moist for fermentation. The manure enclosed in these heaps, although deprived of a portion of the urine, becomes very excellent, and resembles a species of confection such as we have before stated is known under the name of black-butter. This subject is certainly well worth the trouble of the experiment to determine the advantages of one method over the other.

There exists great difference of opinion as to the time when manure should be carted into the fields, and the state in which the manure should be. Most agricultural writers are of opinion that it should not be carted till it is entirely decomposed, when the tissue of the straw has lost its aggregation without being entirely destroyed, when it has much the consistence of butter or fat. Dung attains this state in a shorter or longer time, according to the degree of moisture and heat; in summer eight or ten weeks will be sufficient, whereas in winter it will require twenty or more. Dung which in this state has entirely lost its heat of fermentation, gives out no vapours except when being removed, at which time it has a fetid, rotten smell, and afterwards a smell of musk; its colour is yellowish, which soon becomes brown by exposure to the air. When it is spread upon the land it assumes the appearance of burnt peat; it speedily absorbs moisture and falls to pieces, when it can be easily mingled in a uniform manner with the soil. Others give the preference to long dung not decomposed, and would have it carted immediately from the stable to the land.

If this dung has been subject to fermentation in the stable, where in winter from the greater warmth fermentation will be more rapid than in the dung heap, it will resemble, in a greater or less degree, decomposed manure. Sometimes also fresh-made litter is carried into the field, and, as much as possible, buried in the soil; and it has been thought to produce more sensible effects than fermented dung. For heavy, tenacious soils, particularly where much manure is employed, this last process is doubtless the best; but great care must be taken to bury it well in the furrow, where the dung will of itself ferment and communicate its heat to the soil, whilst the straw will render it light and penetrable to the gases engendered. By means of the ammonia which it produces, it acts strongly upon the insoluble mould which these soils often contain, and produces several effects, of which one of the principal is to bring into action the nutritive portions of the soil which it before contained, and which effect decomposed manure produces in but a very imperfect degree. On the other hand, little benefit, and sometimes even inconvenience, is derived from undecomposed manure on light, poor lands which contain but little moisture, and consequently require all that could be communicated to them by the manure. Its bad effects are more particularly visible when it has been buried so shortly before seed-time, as not to have time to become decomposed; if dry weather follows, the plant will suffer still more from the heat; and if wet weather ensues, the plants, it is true, will grow more rapidly, but they will be yellow and weak, and yield but an imperfect crop: they appear to have had too much hydrogen and not enough carbon. When the dung becomes dried up on the land, after having been covered up, it takes many years to reduce it into fertilizing earth, because it cannot enter into fermentation, but merely falls to pieces. This fact has given rise to the following maxim—that dung which produces no effect on the first crop will produce none on the second. It is, therefore, of the greatest consequence to cart and plough in the manure in a state suited to the wants of the soil.

My own experience, as well as theory, leads me to the conclusion, that it is very detrimental to remove manure whilst in a high state of fermentation; because at that period, an essential part of some of its most active properties would evaporate; but before strong fermentation has commenced, or after it has subsided, it appears to lose little by exposure to air, beyond what it regains in another manner.

There are visible advantages attending the spreading upon the land fresh strawy manure, and to leave it till the ploughings of spring commence, taking care, however, that the water does not wash away the juices, and carry them beyond the field, but that it merely allows them to penetrate the earth.

This method of covering the soil during winter, renders it much more friable, and remarkably fertile. I have often seen the washed, but not rotten straw, thus left on the ground, removed to form fresh litter, and nevertheless, the soil from which this straw has been collected appeared as perfectly manured as if all the straw had been decomposed. Meadows are often manured in this manner. I have so often seen the good effect of short or long dung thus spread over beans and peas, and left there during their growth, upon hot light land, that I have no doubt of its advantage on these two crops, particularly if they have been late sowed. But what is still more remarkable and difficult to explain, is that the following crops on land treated in this manner are also superior to those on which a larger quantity of decomposed manure has been ploughed in. After harvest the stubble should immediately be broken up and covered with earth.

In 1808, I sowed trefoil with spring turnips upon some land which I afterwards strewed with fresh litter. In the autumn of 1809, the trefoil was broken up and sowed with rye, which, in the spring of 1810, was far superior to a neighbouring field which had been manured in the summer upon the fallow. From many experiments tried by myself, as well as other agriculturists, it appears nearly beyond doubt that dung which has passed the highest state of fermentation loses nothing of its quality, but improves even during hot dry weather. This assertion may appear incredible to those who have had no experience on the subject, and I was myself of the same opinion, till my attention was drawn to it by some practical farmers of Mecklenburg, who appeared to have proved the contrary. The strong smell occasioned by spreading manure, leads to the opinion that the evaporation from it must be very considerable; but when we consider that a few grains of musk will for years continue to perfume the atmosphere surrounding it, without sensibly diminishing its weight, it is permitted us to doubt whether the juices evaporated from the manure are very considerable; and if I may believe my own experience, it does not diminish its weight. There is no doubt that whilst in a moist state it undergoes several decompositions, because it absorbs oxygen, and gives out carbonic acid gas, which is again absorbed by the soil, and tends to amend it.

I appears, therefore, that there is no solid ground for objection to leaving the manure uncovered on the land for some time; but if the field lays on a declivity, there will be the risk of the juices being washed off the land by heavy rains.

The practice of leaving the manure on the land in small heaps, as it is unloaded from the carts, is very pernicious; and if it has not yet undergone fermentation, it will be attended with great loss, the wind carrying away the volatile parts, besides which the decomposition will be very irregular, the centre of the heap being entirely decomposed, whilst the exterior will be hardly affected. The most valuable portion of the juices will be absorbed by the soil immediately beneath the heap, rendering that part too rich, which the greatest care in spreading the manure cannot avoid; and the places where these heaps have been, will be marked by the rank growth of the crop, often for several years, whilst the surrounding parts present an impoverished appearance. It should, therefore, be made an invariable rule, that the manure should be spread as soon as deposited from the cart.

The proper time for carting manure varies much with the circumstances and economy of the farm. Where the triennial course with a fallow is followed, the time for carting is between the spring sowing and harvest; the dung, therefore, consists of that which has been collected during winter, which in those farms where the cattle are driven into the stable during the night, has, in addition, the nightsoil of the summer preceding, and of the same spring; the greatest part of this manure is, therefore, entirely decomposed; that which was last placed upon the manure heap being the only unfermented part. The careful agriculturist will, therefore, use those different sorts of manure separately: that which is fresh, he will apply to the damper and colder land, whilst the other portion will be used on those parts which are warmer and drier.

Winter manure is best suited for seed crops, whilst fresh litter is particularly adapted to potatoes, especially in clay soils, because it diminishes their tenacity and allows the plant to come in contact with the atmosphere; and in this case all the manure should be put in the row where the potato is planted, as we shall describe in its place. Other crops, and especially cabbages, do better with decomposed manure; indeed, on light land, this is essential to their success. Afterwards, the manure for beans and peas may be carted, and this can either be buried or spread over the soil. Part of the manure collected since the middle of summer may be used for the corn crops of autumn; though in this mode of cultivation these crops are never thoroughly manured, still an additional dressing is sometimes of benefit: at other times this part of the manure is carried on to the stubbles destined for fallow crops and the vegetables of the following spring. There are various opinions as to the time when manure should be ploughed into the fallows. Some think the ploughing before the last, whilst others think this practice hurtful, inasmuch as the next ploughing is very apt to bring the manure to the surface. For my own part, I am of opinion that it is decidedly better that it should be carted, so as to be buried by the first ploughing, if this ploughing does not take place till near the middle of summer. The method of leaving it to the last ploughing is decidedly bad, and one of the principal causes for the failure of a crop; the manure can never be sufficiently mixed, but remains in lumps, which in some places heats too much, whilst in others it never gets decomposed, but remains nearly in the same state for years. This causes great inequality in the growth of the plants, some being drawn up in strong gross patches, which harbour insects, and others vermin, and are very likely to be cut off in the winter; whilst others are weak and sickly. Some persons are prejudiced against the method of manuring before the last ploughing, from the idea that the manure loses its juices, and favours the production of weeds. On the contrary, the seeds and roots of weeds are much better destroyed by this means; and the young plants buried by the plough, increase the fecundity of the soil. An attentive examination of these facts will remove this prejudice, which has obtained amongst agriculturists from a want of having paid sufficient attention to the subject.

The proper distribution of manure is of such importance, that it demands the utmost care; a too abundant use of it is sometimes as detrimental as not sufficient, from its causing the crops to be laid; there is a maximum of quantity which should be employed, and to exceed which, is attended with great risk of spoiling the crop; it is impossible to fix this quantity, as it must vary with the nature of the soil. Wet, clay land, will require more manure than that which is hot, sandy, and calcareous; but heat has so considerable an effect on the crop, that when the temperature is very favourable to vegetation, the quantity of manure which, in ordinary seasons, would have been only sufficient, will cause the blade to be too thick; it follows, therefore, that the difference between the harvest on rich and on poor lands, in these seasons, is less than it would have been in common or bad seasons; therefore, when manuring for an immediate crop, it is better to be rather below than above the maximum.

Where there is an abundance of manure, it is better not to manure immediately before wheat, but rather to manure for those crops which are never injured by a too profuse vegetation, such as most of the root crops, with the exception of potatoes, which may be over-manured; also maize, cabbages, and such vetches as are cut for green fodder. These products absorb a sufficient portion of the juices from the manure, so that the following crop is never injured. The manure loses, in a greater or less degree, not only its heat and activity, but also its excess of hydrogen and azote, whilst it retains nearly all its carbon.

It is, however, more frequently necessary to pay attention to the opposite error, to see that those fields which require manure, should at least have the full minimum quantity necessary for them; and it is a common rule in this case, to manure fully those principal fields on which we may the best rely for the harvest of grain and straw, even should the less important fields be passed over without manure. It is but too often that this rule has to be brought into practice, nevertheless we must guard against too great an extension of it, by giving to the principal fields more than is necessary, and by this means retrenching from those which have the greatest want of it. It is true that the larger quantity lavished on the good land, may produce more immediate advantage, than if the overplus had been spread on poorer land; but the deprivation of manure on this land, will injure it to a much greater degree than will be compensated for by the more abundant crop on the good soil. Even if there should be a sufficiency of manure for each field, attention must be paid to the soil of each, if we wish to keep them all at the same point of cultivation.

To heavy clay lands a larger proportion of manure must be given at a time, because they can bear it without risk of the crops being laid; whilst a smaller quantity, instead of producing an effect upon them, will probably be retarded in its fermentation, and will consequently remain in the state in which it was carried on. Upon a light, hot soil, the manure is quickly decomposed, and a very abundant supply may have a bad effect, in causing the crops either to fall or to scorch up. The lighter land is, the more it gains by being manured frequently, but with small quantities at a time. It appears, however, an established fact, that in a number of years the two qualities of soil will require an equal proportion of manure.

Manure is generally reckoned by two or four-horse waggon-loads, or by one-horse cart-loads. With a good team a four-horse waggon-load is reckoned at 20 cwt; a two-horse load at 14 cwt.; but nothing is more indeterminate than the quantity of manure loaded into a waggon, as it depends, not only on the strength of the cattle, but on custom, the state of the roads, the distance, &c. The weight of the same manure will also vary according to whether it be damp or dry; when we wish to regulate the quantity of manure according to its weight, it will be necessary to weigh a load from time to time, so as to arrive at a pretty accurate judgment of the quantity carted: this operation can very easily be managed by a steel-yard, which will be found a very useful instrument in rural economy, 20 cwt. 2,000 lbs. (about one ton English) is a medium load for a four-horse waggon: but with a strong team is often carried in the summer time, and on good roads, 30 cwt. 3,000 lbs.*

There is still greater uncertainty in estimating manure according to bulk, because it depends so much on the degree of fermentation it has undergone. A cubic foot of long dung (very strawy dung) will weigh, perhaps, not more than 44 lbs.; whilst a cubic foot of rotten dung will weigh 56 or 58 lbs.; therefore, the quantity of juices contained in the manure has more reference to weight than to bulk.

To an acre of land, five, eight, or ten loads of one ton English, is often employed—the first would be called a light dressing, the second a good dressing, and the third a strong dressing; and would amount to about 8½ ounces upon a square foot.

Carrying the manure on to the land is an operation requiring much attention to the number of hands, of horses, and waggons, to be employed; so that there shall be no waiting for waggons on the part of those occupied in filling them; and also that the horses may be kept constantly employed, and ready to be yoked to the loaded waggon, as soon as they return with the empty one; it is impossible to say how many persons it is necessary to employ; but generally one man and a half, or a man and woman, to each team: but if the manure is in a condensed state, and the work goes on freely, this number will hardly be sufficient. The proportion of manure to be deposited in the field, can be better arrived at by separating the small heaps further, or placing them nearer to one another, than by altering their bulk: a load of one ton will make about nine small heaps of 249 lbs.

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* And even 4,500.—FRENCH TRANS.

each. It will then be easy to determine the distance these heaps should be separated from each other, so as to give the required proportion per acre. Sometimes it is thought advisable to manure one part of a field more than another; the high parts will require more than the lower ground, particularly near the bottom of small hills, for the juices of the manure from these hills will of themselves pass to the lower ground surrounding them. It is not at all an uncommon thing to find the opposite carried into effect, from an idea that manure does little good upon hills; and the labourers are not unwilling to follow a plan which is attended with less trouble; it is, therefore, very requisite that a proper person should be appointed to see that the manure is deposited in the proper places, and to keep the teams to regularity in the distribution of their time.

When, independently of the labourers employed in carting, there are still other hands, it is best to employ them in spreading the manure, which will be done with more facility from its being less consolidated in the little heaps, which is a still further motive for not leaving it on the land without spreading.

It is very essential to divide and scatter the dung well, there must therefore be no want of labourers for this purpose, and an intelligent man should be employed to follow the spreaders, and to separate any lumps of manure which they may have neglected.

It is also necessary to see that the manure is well buried by the plough, for which persons should be employed with forks and rakes to follow the plough, and to separate it in an equal manner in the furrows, when several ploughings are to follow; it is not of so much consequence if a little litter is left uncovered, but great care should be taken that it does not collect in front of the plough, so as to form little masses in some parts, whilst other parts are deprived of it.

In some countries, it is the custom to mix the litter with all kinds of vegetable substances, or even with earth, and to leave it entirely to decompose; by this means, the liquid and volatile parts are better preserved; and if the addition which has been made consists of turf, these parts will be more intimately combined with the earth, and exercise their action upon it. This method causes several decompositions and combinations, which would not otherwise have been attained till a much later period. It is not even beyond probability that the water itself becomes, in part, decomposed, and enters into these combinations in a solid form.

Sometimes all the materials of which the compost is to be made are brought to the receptacle for manure, and there formed into a heap, or, what is still better, the heap is made in the field where it is to be employed, which spares a double carting of the substances collected on the dunghill.

There are two methods of forming these composts.

*(a)*. The several matters of which they are composed are divided into different layers, and placed one above the other; at the bottom of the heap a bed of turf or of earth is placed, five or six feet larger on each side than the extended heap; then a layer, about a foot thick, of the freshest dung that is to be had; above this, another layer of turfts or earth; if there are any other matters capable of putrefaction, they are placed upon this bed, which is covered with another layer of dung, and so on, till it has arrived at a height of five or six feet; it is then covered with another layer of earth. Quicklime is often mixed with these composts, but the lime must not be in immediate contact with the dung, because it causes it to decompose too speedily, and to too great an extent. The lime is therefore placed between two layers of earth, or between the earth and any other substances which are difficult to decompose, such as the leaves of trees, and things of that description. When the sides of the bed of the dunghill have become saturated with the liquor from the heaps, they are turned over, and spread upon the surface. The compost then heats, and fermentation commences, and it is left till this fermentation has subsided. When no more heat is felt in the interior of the heap, it is

turned over, so that the part which was above becomes the bottom, and that which formed the sides is turned into the middle. Sometimes a fresh bed of earth is placed below the heap.

The heap when turned over is made long and narrow, resembling a roof, in order that it may be more exposed to the air; because it is thought that by this means it is increased in weight and quality, and it certainly causes a great increase of nitre. Those, therefore, who pay much attention to composts, turn them over very frequently, in order that a fresh surface may be constantly exposed to the air.

*(b)*. Other agriculturists, particularly when they have a great variety of substances to be formed into manure, bring them all to the place where the dunghill is to be made, and deposit them separately round it. The bed of earth for the bottom of the heap is then formed in the middle; the labourers then surround the heap, and each, with a shovel, throws the substances as they lay round it into the bed, by which means the whole mass is equally mixed throughout. Thus loam, earth, turfts of grass, moss, the leaves of trees, particularly of pine trees, sawdust, and the remains of animal or vegetable matter, and very often, in addition to this, lime, ashes, soot, and fresh litter, are all incorporated, and the mixture wetted with the liquid which drains from the manure, or with urine. A larger or smaller quantity of lime is employed, according to the difficulty or facility with which the substances forming the mass can be decomposed; those substances containing acid are slow of putrefaction, and, therefore, will require more lime; whilst, on the contrary, if there is much animal matter in the compost, lime may be spared. This dunghill should, like the former, be allowed to remain quiet till the fermentation is past, when it should be turned over several times.

Those who disapprove of decomposing stable manures on a dunghill, look upon this mixture as a useless increase of labour; this manure, they say, would be sufficiently mixed and incorporated with the earth by ploughing, and it would have been accomplished in a far simpler and easier manner; besides, they allege that the putrid fermentation of manure in the soil is very advantageous; and, as far as concerns cold argillaceous soils, they are quite correct. But what is a stronger objection to the general use of those composts is, that in them stable litter cannot be brought into use till the year following, which is of great importance where manure is not over abundant; for, independently of the products immediately drawn from the application of fresh dung, these products will again yield more manure before the compost will be ready for use.

It appears, therefore, that these composts should only be made where there is an abundance of manure, or where there is a considerable quantity of substances not easy of decomposition; and in these cases it will be found of great advantage as a sort of reserve, and will ensure the farmer a rich return for his labour.

Numerous experiments have tended to prove that the best way of using compost consists in spreading it over the soil without burying it. It is carried after the seed ploughing, and spread abroad by being thrown from the waggon in shovelfuls by men stationed there; the seed is then sown in the ground, which is afterwards harrowed, or receives a very light ploughing. The compost may even be spread over the ground after the sowings have taken place, if such a proceeding be deemed expedient. It is sometimes spread over autumnal corn, but is more frequently reserved for the spring cereals when their vegetation has commenced. This method of manuring is productive of the most astonishing effects, while a very small portion of the compost is actually used. The testimony of persons who have themselves practised it, as well as the high estimation in which it is held throughout whole kingdoms, serve to attest its utility and the benefits derived from it. In Hertford, a large county of England, this practice has been adopted from time immemorial; indeed, they scarcely use any other species of manure. The English term this mode of manuring "top-dressing." The system of cultivation in the above-mentioned county is not otherwise distinguished by any peculiarity, yet the crops are remarkably fine, and the agriculturists there declare that they are never known to fail. These men attribute an almost magical influence to the practice of spreading compost over the cereals during their vegetation. According to them, when wheat has been partially destroyed by the severity of winter, or barley injured by frost, drought, or humidity, becomes diseased, and can scarcely be said to vegetate, the compost produces the most marvellous effects as soon as it is applied. They assert that the plants may almost be seen to renovate and regain their verdure. This beneficial effect of compost is confirmed by the unequivocal testimony of almost every writer on English agriculture.

It is therefore evident that not only actual advantages but also security against evil is to be derived from the possession of an active manure of this nature, and without any sensible diminution of that dung which is absolutely necessary to meet the wants of the current year.

In many writings, an innumerable variety of directions for compounding this mixture are to be found, in which the exact weight and measure of each separate substance is given with all the formality of a medical prescription. But this is downright pedantry; all that can be said on the subject resolves itself into the following precept: "Collect every vegetable, animal and mineral substance which you have at your disposal, taking care, however, that the latter consist of such matters as are proper for the purpose; mix them well together, add a little quicklime and as much earth as will absorb the gases evolved by these various substances; allow them all to remain in a heap until they are thoroughly fermented, and then mix or stir them repeatedly until they are transformed into an homogeneous mass.

Where there is a scarcity of straw, various vegetable substances are used for the purpose of absorbing and retaining the excrementitious matters, and forming a dry bed for the cattle, as well as for increasing the quantity of the manure; because the vegetable substances devoted to this purpose are much sooner induced to enter into putrefaction when mingled and saturated with animal excrements than if left to themselves. The propriety of using, and the selection to be made of these varieties of litter, therefore, depends as well on the qualities which render them fit to furnish the cattle with a dry, healthy bed, as upon the greater or less disposition which they have to enter into decomposition.

The litter in most general use, after straw, is the *leaves of trees*, and especially of those belonging to the family of pines. The forests of those countries in which there is almost always a scarcity of straw are chiefly composed of pines or of trees of that kind, consequently an abundance of leaves can be collected from the ground and intermingled with mosses. When these leaves are mixed with the excrements of animals, they become decomposed much sooner than they otherwise would be; nevertheless they retard the fermentation of the manure, which must then be allowed to remain in the heap much longer than would be necessary if the excrements of the cattle were mixed with straw only. When once the decomposition has taken place, the dung, so far from being inferior to that which is simply composed of straw and excrements, appears to be in no small degree superior to it, because the pine-tree leaves contain a far greater proportion of nutritive juices than the straw.

*Oak* leaves are not easily decomposed, and contain an astringent matter which is highly injurious to vegetation so long as the leaf remains undecomposed. Manure, therefore, which is partly composed of oak leaves must not be removed from the heap for a considerable period, if we would derive actual benefit from the use of it. If it is placed in the ground before it is thoroughly fermented, its leaves remain there for a long time before they rot, and may prove rather prejudicial than otherwise, especially to light soils.

The leaves of *beech*, *walnut*, and *chesnut trees*, while yet green, certainly appear to be even more injurious to vegetation than those of the oak, since little or no grass ever grows under these trees; but when mixed with dung, they soon lose their baneful properties and rapidly decompose. Myself and several brother agriculturists have seen much more beneficial effects resulting from the use of manure made with the leaves of beech, walnut, and chesnut trees than from that which contained oak leaves.

The leaves of the *alder*, *willow*, and *poplar* also seem to have the property of being rapidly decomposed; but they possess little consistence, and tend very slightly to increase the volume of the excrements which they receive. There are many districts and agricultural undertakings in which these leaves are reckoned upon as an essential part of the litter, because nearly or quite the whole of the straw is reserved for winter fodder for the cattle; and on account of the general arrangement of things, it would be absolutely impossible to do without this additional litter. But it is well known that woods and forests are in no small degree injured by this practice, and the harm done to the trees far surpasses the scanty profit derived from this false economy. The obligation of furnishing leaves for this purpose has become an exceedingly burdensome tax on the proprietors of parks, forests, or other wood lands, and one which it is to be feared, from the existing system of cultivation, there will be considerable difficulty in abolishing. When the owner of the forest himself makes use of the privilege, and uses it with moderation and discernment, there cannot be a doubt that he will occasionally derive great and real benefits from it; but those who hold this right over the property of another, are seldom very particular as to the manner in which they exercise it.

In countries where *heath* and *broom* are very plentiful, these plants are used for litter, when the substances which we have been describing are all exhausted. Sometimes the heath is mown or cut, while at others it is torn up from the soil with a species of hoe adapted for the purpose; and thus, not only the plant itself, but also that portion of the mould which clings to its roots, is taken away. Although this plant can hardly be said to become decomposed in the course of a year, nevertheless the animal excrements with which it is mixed, render it so soft and deprive it so completely of the astringent matter which it contains, that when transported to the land it soon becomes perfectly decomposed and divided. In a part of the principality of Luneburgh, of the bishopric of Breme, and in Pomerania, many persons regard this plant as so indispensable to rural economy, that they hesitate to extirpate it or to bring those spots which are overrun with it into cultivation, because they cannot conceive the possibility of doing without this plant in the formation of their manure; in fact, it will be impossible to do without it so long as the present arrangement of their rural economy remains in force. Many agriculturists who hold the right of gathering heath on the land of others, and who rigidly exact that right to the uttermost, are enabled to maintain land of the most inferior quality in a wonderful state of fertility. But as this plant grows slowly, especially when the surface of the soil is torn up with it, it will probably require a hundred acres of heath to maintain an acre of arable land in good condition; this practice, therefore, can only be carried into effect on small estates, surrounded by an immense extent of uncultivated land. If the heath must be gathered from any considerable distance, a great deal of time will be lost, and the labourers and teams will be employed in this operation during a considerable portion of the year. Frequently it is actually more difficult to procure sufficient heath to ameliorate an acre of land than it would have been to cover the same extent with marl or mould. Nevertheless, few appear startled by the expenses attendant on the former proceeding, while they would pause ere they ventured to adopt the latter; so much does prejudice and the force of habit govern our actions.

The agriculturists are not contented with spreading the heath under the cattle, but they also mix with the manure the portions of earth and turf dragged up at the same time, and form a heap of these substances in the field, which they suffer to remain untouched until the whole mass is thoroughly decomposed. When this manure is mixed with a small quantity of animal excrements and is thoroughly consumed, a small portion of it is spread over the fields, where it will often produce very fine crops of rye and buck-wheat. As very few weeds shoot up from it, the land does not require a fallow, but is capable of bearing six or seven consecutive crops, which, however, progressively decline in value. Persons who are not aware of all the difficulties attendant on the acquisition of this manure, regard it as in the highest degree desirable and beneficial, and heath lands as of the greatest possible utility. The celebrated De Luc, in his travels through these countries, considered this practice as a weighty reason for deciding against the division and enclosure of commons and uncultivated lands. There can be no doubt that there are cases in which heath may be used as litter with the greatest possible advantage. This is especially the case in sheep-folds, where this plant is readily decomposed by the action of the excrements of these animals.

Many other vegetable substances, as reeds, rushes, aquatic plants, the genet or waythorn, moss, fern, &c., may be used as litter when nothing else can be obtained. Some of them, and especially those which when burned yield a great deal of potass, produce a very fertilizing mould. The more green and succulent they are when placed under the cattle to receive the dung, the more rapidly do they decompose; but, when in this state, they do not afford so wholesome a bed for the cattle. After having become dry, these plants are not decomposed without difficulty; and, therefore, the manure of which they form a part must be suffered to remain on the heap for a greater length of time. Reeds are not easily decomposed unless they have been on the roof of some building for a considerable period, and become softened by exposure to the atmosphere; they then appear to produce a particularly good manure.

The sweepings of barns should not be mixed with manure without the greatest circumspection being exercised, if we would avoid the danger of infesting the land with weeds. The vitality of the seeds contained in these sweepings is not entirely destroyed even by the process of fermentation; the best way of making use of these matters is to mix them with the manure intended for the meadow land.

In low, damp situations, a substance similar to moss is frequently found, filled with all sorts of aquatic plants, and which may be advantageously substituted for peat. When this substance is dried, it is peculiarly adapted for the formation of litter, because it is promptly decomposed by the dung, has a strong tendency to absorb moisture, and produces a valuable kind of manure. But it ought not to be used while any other kind of litter can be procured, because it might better be transported to the fields in its natural state, where, after having been mixed with straw manure, it will be found to decompose rapidly and thoroughly.

Sometimes, and especially in sheep-folds, turf or peat is used for litter, when it is of a light texture. We shall have to treat of this subject, and of the properties of this substance, when speaking of manures in general.

Many agricultural writers have advised the use of earth as litter. Turfs taken from places where they are altogether useless, may thus be converted into mould, and afford an excellent manure; and there is no doubt that this substance is considerably ameliorated by its transit through the stable, where it absorbs the urine and superabundant humidity of the excrements in general. But pure earth can never actually become manure, it can only absorb the dung and a portion of the urine. Besides its being a very difficult matter to keep the cattle dry on such a bed, this practice is productive of much heavy labour and cartage, as the earth has, in the first place, to be dug up and brought to the stable or cow-house, in order to be thrown underneath the cattle, and subsequently taken away and transported to the fields. I do not think that I ever saw this practice carried into effect, nor am I aware that it exists any where, excepting in those English counties, Norfolk and Suffolk, where the sand thrown up by the sea, and which is for the most part composed of shells and lime, is carted while dry, and conveyed to the stables to be employed as litter; this is, however, only the case in towns. The dung which is mingled with this species of sand ought to be very active.

The transporting of earth, and especially marl, to the dung pits or steads, and placing it there for the purpose of saturating it with dung water, is quite another matter. An excavation in the form of a basin is made in the middle of the heap, into which the fluid is poured; and, in order to facilitate the introduction of the liquid or dung-water, holes, extending to this basin, are bored in the heap, with a pole or bar of iron, in different places. When the earth is sufficiently impregnated with this fluid, it is conveyed to the fields. Sometimes the dung heap is surrounded with a wall of earth, in the form of an enclosure or embankment, on which a little canal or gutter is hollowed, to receive the superabundant moisture of the heap. When the wall of earth has remained in this state for several years, and has consequently absorbed a great quantity of the emanations arising from the yards in which the cattle are enclosed, it is conveyed to the fields, where it produces wonderful effects. But, previously to undertaking this operation, however beneficial and useful it may be in itself, the expenses which will be occasioned by the carrying of the earth to the farm yards, and thence again to the fields, as well as the labour attendant on the watering of it, should be calculated.

However general and advantageous the custom may be of making use of straw and other substances for the purpose of collecting the excrements of the animals, and forming a litter for the cattle, it is not universal. Cattle are not unfrequently kept in stables and cow-houses, both during winter and summer, without any litter, especially in countries and farms where breeding and fattening of cattle form the principal aim and object of the undertaking. The arrangement of stables devoted to this practice varies considerably; in general, the floor on which the cattle are stalled is formed of boards, which incline slightly from the head to the hinder parts of the animals. At the edge of this flooring, and behind the animals, is a gutter or conduit of masonry or plaster, into which all the excrementitious matters fall, or are swept with a broom, as soon as they are voided. There are often pumps or water-courses in these stables, which are immediately used to wash away the excrements. In order that the animals may not soil themselves, or become dirty, care is taken to keep their tails suspended; this is done by means of a fine cord, which, passing over a pulley attached to the ceiling, has a weight at its opposite extremity proportionable to the weight of the tail, which is thus kept from falling on the floor and becoming fouled, and, at the same time, is not drawn up too roughly. Or, the cattle are lodged on a plaister floor, pierced with holes communicating with a reservoir of masonry or cement, in order that they may be kept dry. The urine and liquid portion of the manure collect in these reservoirs, and thence flow out through gutters into the tanks or pits intended for their reception. That portion of the excrements which retains its consistence is thrown behind the animals against the wall, and so much care is taken each time to cleanse the place, that it is as neat and clean as the floor of a room. This practice not only contributes to the health of the animals, but also to the quality of their milk, especially as, wherever it is pursued, they are carefully curried down and brushed.

In other undertakings, recourse has been had to a far more simple arrangement, but one that is not so beneficial to the cattle. Then the buildings destined for the animals are so narrow that they are obliged to draw up their hind legs in a manner wholly contrary to nature, in order to be able to face the manger. Behind them is an excavation of a foot and a half, or two feet deep, and into this the excrements and the urine of the animals fall, provided that they are not standing aslant. They must, therefore, be tied very close together, in order to compel them to face the manger exactly, both while standing up and lying down; which they certainly would not do if they had the power of moving either to one side or to the other. The cattle must be well accustomed to this fashion, or their legs will inevitably slide backwards and fall into the excavation; and thus the legs and thighs will be liable to excoriation and injury.

Whatever may be the difference which exists between these two methods of stalling cattle, it is not in that alone that the management of the manure varies. The large excrements are either carried out of the stable, and, having been mixed with straw, are made into regular heaps, care being taken that the pure dung shall be in the centre, and that which is mingled with straw on the outside, and these heaps are occasionally watered with dung water; or else, a slight litter of straw is occasionally strewed under the cattle; a little water is pumped up and added to the excrements which the gutter or excavation already contains; the straw is thrown into this gutter by a fork, and there worked backwards and forwards in order to make it take up as much of the large excrements as possible, and then conveyed to the dung heap on the outside of the stables. More water is subsequently pumped up and carefully mixed with those excrementitious matters which remain in the gutter, until the whole forms an equal and flowing liquid, which is then propelled through the open gutters to the tanks or reservoirs intended for the reception of the liquid manure.

By these means the large excrements mingled with straw are kept entirely separate from the liquid manure, and either one or the other is made use of as circumstances require.

It is necessary to have several tanks or reservoirs for the reception of the liquid manure, and also that the canals should be constructed so as to fill first one and then another. In fact, before this fluid can be used with any degree of advantage, it must have undergone a species of fermentation or putrefaction; until this putrefaction has been brought about, it must be covered up and kept from contact with the open air, and only stirred now and then. These tanks or reservoirs are successively emptied when the fluid which they contain has reached the proper degree of fermentation, and are then filled again.

Very great commendation is bestowed on this practice, and on the value and quality of the manure which it produces; but I cannot help considering that a great deal of exaggeration must be mingled with it. It is asserted that with the assistance of the straw as much dung is obtained as there would have been if the animals had been littered down in the usual way, and that this dung is rendered more active and fertilizing by the pains which are taken to collect it: and it is further asserted that they have liquid manure in addition, which, from the effect which it produces, is equally as valuable as the concrete dung, if not more so; and that, consequently, this practice produces twice if not thrice as much manure as would have been obtained under the ordinary course of proceeding. This seems to me to be such an absolute contradiction, that I cannot allow myself to be convinced of the truth of these assertions,* until well authenticated comparative experiments shall have attested their correctness. I do not mean to deny the fact that a much greater quantity of nutritive juices may be produced by this than by the ordinary mode of proceeding, because more complete decomposition and new combinations of elementary matters may thus be brought about. General experience has proved beyond a shadow of doubt, that liquid manure produces a very beneficial effect, especially on sandy soils, to which it restores some portion of that consistency of which they have been deprived by reiterated ploughings and ameliorations of strawy dung. All kinds of animal and vegetable refuse are thrown into the tanks destined for the reception of the liquid manure, and especially human urine.

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* The actual advantages arising from the use of animal excrements in a liquid form as manure, consists in that assimilation to the organs of plants which these excrements have undergone during the fermentation of the liquid, and in the greater degree of facility which a liquid form gives them of coming into immediate contact with the plants and being immediately absorbed and diffused throughout their substance, and thus reproducing vegetable matter promptly. There is not a doubt that a given quantity of excrements may, under this form, yield double if not quadruple as much produce as they would have done had the excrements been employed in a concrete form. This practice may, therefore, prove exceedingly advantageous in rural undertakings which do not possess a sufficiency of manure, supposing that the texture of the soil is light enough to admit of the constant use of liquid manure without any bad effects being produced.—FRENCH TRANS.

Although it is far from being my intention to dispute the advantages attendant on this practice, yet I think that previous to the adoption of it, it would be as well to be assured that these advantages will repay all the labour and care which are requisite; in order to effect this end, it should be brought fairly into comparison with our ordinary course of proceeding, in which also everything should be so arranged that no particle shall be wasted. With us, as soon as the dung possesses more humidity than it can retain, the liquid that oozes out is collected and applied; but if, as too often happens, the situation of the dung steads or heaps is not carefully arranged, and this fluid is allowed to drain away without being collected, then there can be no doubt that an essential portion of the manure is lost, particularly if the cattle have been fed on green meat, or on very succulent fodder. Reservoirs or tanks for the reception of those liquid portions of the manure which, having passed through the heap, ooze out, and would drain away and be wasted if not collected, are necessary appendages to every farm yard.

The care which must be bestowed on liquid manures, and the difficulty of transporting them, are neither so great or so laborious as many persons suppose. The liquid can easily be drawn up from the stone or cement tank which contains it by means of a pump, and transferred to large vats or casks constructed for the purpose.

These vessels are then placed in waggons for the purpose of being carried to the fields; at the back part of them a hole or opening is made; to which is attached a box or board,* into which or on which the liquid falls, and is thus diffused in an equal manner over the land as the cart moves onward. The cart is driven faster or slower according as it is deemed advisable to manure the soil more or less abundantly.

The liquid manures are specially devoted to those crops which will bear rich ameliorations, which are prompt and energetic in their action, as the wild cabbage. Some agriculturists reserve them for clovers and other artificial meadows, or for natural pastures. With regard to cereals, they may easily be rendered too thick if the soil on which they are sown is ameliorated with manure of this kind, unless, indeed, the liquid is very weak or has been diluted by an admixture of water. Liquid manures are never so advantageous as when applied to sandy soils, which they render tolerably consistent and more adapted for the retention of moisture. In soils of a mediocre quality, liquid manure and dung are employed alternately; but the use of liquid manure will never replace that of dung on tenacious and argillaceous land.

Liquid manure can never be so advantageously employed as in restoring the requisite degree of moisture to dung which has become so dry as to cease to ferment. Wherever this is the case, the heap should immediately be watered with this fluid.

Lastly, in enumerating all the various animal manures, we must not omit to mention that arising from the folding or cotting of sheep or cattle on arable land. The animals are turned during the night into a fold enclosed by lathes, hurdles, or twigs. By these means the excrements, and even the vapours which emanate from their bodies, are concentrated within the space assigned to them; and in order that these substances may be more thoroughly incorporated with the soil, the land generally receives a slight ploughing before the cattle are enclosed on it.

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* Several well-constructed carts for the distribution of liquid manure have been invented by our most experienced agricultural implement makers.

This practice is usually followed only with sheep. A somewhat similar proceeding has, however, been occasionally adopted with the other kinds of cattle. Oxen which have been put up to fatten are enclosed in a certain space of ground in the neighbourhood of the most abundant pasturage, or of those divisions of fodder which are destined for their consumption; straw is littered over these enclosures, which mixes with the excrements voided by the cattle and serves to collect them. By these means the dung is turned to great account; whereas, if it were voided over the pasturage, it would be rather injurious than otherwise, and, in a great measure, wasted. Some persons have even gone so far as to establish an enclosure of this nature for geese, and profess to have derived considerable advantage from it. These things are, however, of rare occurrence, the practice is in general solely confined to sheep; and opinions are yet very much divided with respect to the advantages and disadvantages that result from folding.

It still remains a question whether this close confinement of sheep be injurious to their health and fleece. It is only the strongest and most vigorous breeds that can support it. In England there are many fine long-woolled breeds to which it proves fatal; although the same animals when allowed their liberty, and suffered to run in the open air, are vigorous and healthy both in summer and winter.

Although the sheep of our country, and even those of pure Spanish breeds, can support this system without being killed by it, nevertheless they thrive better when allowed to run at liberty during the night, or sheltered beneath a roof from the inclemency of the weather: this practice is very injurious to lambs.*

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* The effect of warmth upon the consumption of food by animals, although by far too little understood, is also an examination fraught with instruction to the farmer. In an experiment of Lord Ducie's, at Whitfield, one hundred sheep were folded by tens in pens, each pen possessing a covered shed. From the 10th of October to the 10th of March each sheep consumed, on an average,

Independent of the difference in the health of the animals, folding at night in littered yards combines all the advantages of folding on arable land without any of its disadvantages; the excrements there become mixed with the straw, and produce a manure which, if not quite as active as that yielded by the fold or pen, is more durable in its effects.

On the other hand, the pen or fold has this actual advantage, it saves the labour and expense of carrying the manure; and the further the fields are removed from the farm buildings, the greater is the advantage derived, especially when the roads which lead to them are bad. Hence arises one great inducement to the agriculturist to have recourse to this practice, especially in mountainous countries, and on hill-farms. Another, is the want of straw and other substances which might be used as litter.

Thus, then, it is evident that in this, as in many other cases, locality and convenience lead persons to adopt one course of proceeding rather than another.

English agriculturists also allege another objection to this system. They assert that sheep-pasture lands rapidly deteriorate when deprived of the excrements voided by these animals during the night, and improve as visibly where the contrary course is pursued; and bring forward in support of that assertion numerous incontestible experiments, which tend to prove that in the former case the number of sheep which they will keep is annually decreased, while under the latter they are capable of supporting a larger number every year, and become progressively ameliorated; that, lastly, the difference between the fertility of sheep pastures which are allowed to receive all the dung voided by the animals during the night and those which are deprived of it, is very striking.

In reply to this objection, others have urged that if

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20 lbs. of Swedes daily. Another one hundred were folded in pens of a similar size, but without sheds attached; they were kept during the same time, and their daily consumption of Swedes amounted to 25 lbs. each. And yet the sheep which enjoyed the protection of the sheds increased in weight 3 lbs. each more than those left unprotected.—*Jour. Roy. Ag. S.*, vol. iv., pp. 222—230, vol. i., pp. 140—147.

sheep were allowed the liberty of a considerable extent of pasturage during the night, they would still huddle as closely as possible together; and consequently, instead of diffusing their excrements over the field, would void them all in one place, where this accumulation would tend to injure rather than ameliorate the pasture. And they likewise state that the sheep invariably congregate as nearly as possible in the same place every night; but I have never found this observation in the works of any English agricultural writer, even of those who are most favourable to the practice of folding sheep. In my opinion, sheep, which are turned into pastures surrounded by hedges, and which are not driven together by the shepherds or their dogs, will never acquire this habit.

The following regulations must be attended to in folding sheep:—

1. The fold or pen must never be made larger than is absolutely necessary: sheep have a natural propensity to crowd as closely together as possible. If, therefore, the enclosure into which they are turned is larger than there is any absolute necessity for it to be, one portion of the land will be thoroughly ameliorated, while another will be very imperfectly manured. Not more than ten or twelve square feet should be allowed to each animal, if we would have them manure thoroughly the space assigned to them.

2. The hurdles of which the pen or fold is composed ought not to exceed ten or twelve feet in length, in order that the shepherd may be able to carry them from place to place and fix them in the ground. The proportionate number of these hurdles need not be increased in exact ratio with an increase in the flock of sheep. If we suppose each hurdle to be ten feet long, and that each sheep ought to be allowed a space of ten feet in extent, a flock of two hundred animals will require eighteen hurdles; and a flock of three hundred only twenty hurdles, if the pen is constructed in the form of a square. Besides, a small flock requires equally as many attendants as a large one, and consequently the expense of each separate animal is di-

minished in proportion as the aggregate number is increased. On this account, it is seldom deemed advisable to fold less than three hundred sheep.

The comparative richness of the amelioration bestowed on land by the practice of folding, varies considerably. Some have endeavoured to define it according to the greater or less extent of the space on which the animals are enclosed; others, by the time which they are suffered to remain on one spot. But these data are very unsatisfactory, because the quantity of excrements voided by the sheep must depend entirely upon that of the food which they have consumed; and their value will be in proportion to its fattening quality. If the pasturage is abundant, a given number of sheep will manure the spot on which they are enclosed as effectually in one night as they could do in two or three if kept upon scanty pastures. Every one must be struck with the truth of this observation.

Folding is divided into three classes, which are designated "complete-folding," "half-folding," and "extra-folding." If the pasturage be of a tolerable quality, the folding is said to be complete when six hundred sheep are penned on an acre of land for three nights; or, what amounts to the same thing, when one thousand eight hundred sheep are folded on an acre for one night. A slight or half-folding is said to have taken place when one thousand two hundred sheep have passed the night on an acre of land; and the ground is said to have received the benefit of an extra-folding when the same extent of space has been occupied by two thousand four hundred sheep.

Even supposing the pasturage to be always equally good, the length of the nights will cause no slight difference in the effects of the folding. When the nights are shortest, the animals are not in the fold more than eight hours; whereas, during the long nights, they remain there for twelve hours, if not more. To this consideration must be added another, namely, that in most agricultural undertakings sheep, in general, receive but a scanty pasturage during the term of the short nights, and that they are much better fed in the spring when they are depastured on the meadow or fallow lands previous to their being broken up, or in the autumn, when they are turned on the stubble fields. In order to compensate for this inequality, some persons have divided the long nights into two equal portions, and have caused the sheep to spend half of the time in one place and half in another. Where the shepherds are not accustomed to this mode of proceeding, the best plan will be to contract the limits of the fold during the short nights, and thus make up the difference by diminishing the number of hurdles, or arranging them so as to enclose a smaller space. A similar number of hurdles will embrace a much greater circumference when set up in the form of an exact square, than they would do if made into a long square. Twenty hurdles, each twelve feet long, if set up in a square form, will enclose twenty-five perches; but if the same number were arranged so that there should be eight on each side and only two at each end, they would not then enclose more than sixteen perches. The Count de Powdewils has drawn up a table for regulating the proportionate space according to the length of the nights. It will be found in vol. i. "Annals of Agriculture," and clearly indicates the intensity of the manuring which will be derived from the form given to the fold and the arrangement of the hurdles.

Sheep are generally driven into the fold at sunset, and not let out again until the dew is evaporated, because that vapour would be very likely to prove injurious to them on account of the voracity with which they then eat. Before they are let out, they are moved about in the fold in order that they may empty themselves completely, and that no portion of their excrements may be lost on the road.

The kind of manure produced by folding is easily decomposed, and, consequently, acts with great promptitude and energy. It produces a peculiarly sensible effect on the first crop; but its effect on the second is very slight, and where only a slight folding has taken place it is not felt at all. It is only an extra-folding, when two thousand four hundred sheep have been enclosed on an acre of land, that is capable of producing effects which endure until the third crop; especially if, immediately after the folding, rape, or some other produce of the same or a similar nature, is sown instead of grain crops. It is thus that the greatest amount of profit can be derived from this practice. Should such a course not be adopted, there will be every reason to fear that the cereals will be laid, an inconvenience which is too often induced by ameliorations of this nature.

In general, when the farmer wishes to ameliorate his land very considerably for the corn crops, he first manures slightly with stable manure; and then, after having buried that by ploughing, he folds a few sheep there.

Corn crops succeeding the folding of sheep, especially of a large flock, acquire bad qualities, which cause the grain to be rejected by bakers, brewers, and distillers of brandy. We shall have occasion to return to this subject hereafter.

The soil is usually ploughed before sheep are folded on it; and as soon as the folding has taken place, they hasten to bury the manure thus deposited on the ground, by a superficial ploughing. Although this proceeding is universally adopted, I have had my doubts as to the eligibility of it since I have learned several experiments being made by agricultural friends of mine, who assert that they have seen the most beneficial effects resulting from folding, when the manure was suffered to remain on the surface of the soil for a considerable period. There is no doubt that great advantages have been derived from folding sheep on land after the seed was sown in it. I have seen wonderful effects resulting from an amelioration of this nature bestowed on a field in which potatoes had been planted.

The practice of folding is sometimes adopted for the purpose of manuring hilly or mountainous pasture lands, or artificial meadows, and with great success, especially where these places are difficult of access, and it is almost impossible to transport manure to them in the ordinary way.

Many persons who are prejudiced against immediate folding, and who have a superabundance of straw for litter, and who wish to improve distant or hilly parts of their farm with sheep-dung, make moveable enclosures in the neighbourhood of these spots, which they strew with an abundance of litter, and then drive the sheep into them. Sometimes the animals are only confined in these folds at night; at other times they are kept there during the day also, especially when these folds are sheltered by trees. Thus, they have the dung made in immediate proximity to the fields on which they wish to use it, and an immensity of labour is spared, for the carriage of the straw is far less expensive than that of the dung. In these moveable folds the sheep may be allowed more room, and the straw affords them a more healthy bed than would be furnished by the damp ground.

As all animal substances form very active manures, the fertility of the soil and the amount of its products will be very sensibly augmented, if not only the excrements of animals, but also the bodies of those animals which die, and all the offal from those which are slaughtered, are carefully preserved and used as manures; and no portion, however small, of these manures, are suffered to be lost or taken away from the great and universal circulation of nature.

Animal bodies, when deprived of vitality, form a peculiarly active manure. If these are collected together in trenches, or enclosures walled round, covered with quicklime, mixed with earth, and subsequently, when they have lost their putrid and offensive smell, which is soon carried off by the lime, the whole mixture be well stirred and mingled together, an exceedingly active manure will be obtained. But if, on the contrary, these substances are suffered to decompose in the open air, buried deeply in the ground, or thrown into the water, they are withdrawn from the circulation of organic matter, and a considerable portion of the elements of life are thus lost.

Even bones are softened by the admixture of quicklime, and may then be powdered without difficulty. After this preparation they produce wonderful effects on land.

On the sea-coast, fish are not unfrequently used as manure; and also occasionally at the mouth of large rivers, as is the case when an enormous quantity of herrings is thrown on the shores of the Elbe. But these fishes must be covered with quicklime, and subsequently mixed with earth, if we would derive that amount of benefit from them which they are capable of producing. Experience testifies that this mixture is productive of wonderful effects when spread over the sowings; but that when the fish are scattered over the soil and buried before they are thoroughly decomposed, they are positively injurious in the first year, and productive of little advantage in the second. The same may be observed with regard to rancid oil of herrings, which is sometimes used as a manure. When undecomposed, it is, in common with all other oleaginous substances, prejudicial to vegetation; but when its decomposition has been effected by means of lime or alkalis, it becomes a very active manure, as numerous experiments tend to prove.

Horn must also be included in the list of highly efficacious animal manures. It contains a larger quantity of decomposable animal matter than bone, and is decomposed with less difficulty, and is almost entirely dissolved in nitrogen, hydrogen, carbonic acid, phosphorus, and sulphate of lime, and then apparently enters into divers combinations with them in various proportions, producing thereby exceedingly fertilizing matters. The shavings or clippings of horn, or the residue left by turners, comb-makers, &c., are most frequently used for manuring land. The most minute portion are the first to become decomposed; but, although their effect is most sensible, it does not last more than a year. But this effect may easily become so great as to cause the chief part of the cereals to be laid; besides, on on account of this excess of fertility, they are longer in arriving at maturity: the grain does not ripen so soon, the ears of corn are more subject to rust, the grain itself contains less farina, and, in short, the crop has all the defects of cereals sown on land which has been ameliorated by the folding of sheep; possibly because both contain too great a proportion of nitrogen. It is, therefore, better to ameliorate those soils with horn which are intended for the production of crops which are not liable to suffer from an excess of manure. If some few larger pieces are found among the shavings, or if hoofs are chopped and mixed with them, the decomposition goes on more slowly. These matters do not produce much effect in the first year; but when once the effect is produced, it is more durable. English agriculturists consider that from five to six hundred pounds of this substance is a sufficiently rich amendment for an acre of land. I have used twenty-four bushels of these shavings on that extent of land. A bushel weighs from twenty-four to thirty-two pounds, according as it is composed of shavings or large pieces. The best plan is to determine the quantity by measure rather than by weight, because the thin shavings weigh less than the clippings, while their effect is more prompt and energetic.

The hoofs of animals, of which butchers frequently have an immense quantity by them, should be chopped into small pieces previous to being spread over the land; but this is by no means an easy task, unless the hoof has been previously softened by being steeped in water, to which a little lime and ashes have been added, for a considerable time; but hoofs may be used whole with considerable advantage for the purpose of ameliorating meadows. Where this is done, holes are made in the ground, about a foot and a-half or two feet apart, and into each of these is put the hoof of an ox, full of water. An abundance of grass shoots up round this hoof on the first year; on the second the amelioration extends yet further; and on the third year, the hoof being totally dissolved, the whole of the meadow is ameliorated.

The refuse of the shambles, consisting of blood, hair, and all kinds of filth, likewise forms an excellent manure: mixed with earth, and used in small quantities, these substances produce prompt and energetic effects. It would be almost extravagant to make use of them or bury them as we should other manures, as they can be employed with so much more advantage in the form of compost.

The same may be observed with respect to the offal of tan-yards. I here, of course, allude to the animal portions, and not to the tan. This is also a very active species of manure, and one which should be employed in the formation of compost, and spread over the land sparingly.

The hair and wool of animals is composed of the same constituent parts as horn, but these substances do not decompose so rapidly; at least, until they have been mixed with a little lime. In England, woollen rags, feathers, and old hats are carefully collected and sold as manure. They are thrown into trenches, sprinkled with quicklime, and then left to decompose; and, subsequently, the matter thus formed is mixed with the soil. It is an undeniable fact, that if nothing which could by possibility tend to accelerate or enrich vegetation were wasted or suffered to be lost, an immense increase of products would be the result.

Shoes and old leather are not very easily decomposed by the simple action of the atmospheric air, but if mixed with a little quicklime they speedily enter into a state of decomposition, and are transformed into a mucilaginous substance. The residue of the grease tubs of tallow-chandlers, when not used for the purpose of making soap, forms an excellent manure, but one which ought only to be applied in the form of compost.

The scum taken from the boilers of sugar-bakers, and the residue of these manufactures, consisting, for the most part, of blood, mucilage, and lime, must not be omitted in the list of animal manures. In rural undertakings, in the neighbourhood of large towns, an abundance of this substance can always be procured; and it is a general opinion that there is no variety of manure which can surpass it in the effects which it produces, or which goes so far.

All the last-mentioned species of animal manures are only within the reach of those agriculturists whose farms or estates are situated in the vicinity of large towns or thickly-populated districts.*

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* Since M. Thaer wrote, another animal fertilizer, the guano, has been added to the list; of this large quantities are now importing into England. Guano is, it seems, the European mode of pronouncing the Peruvian word "huano," or, manure. This substance exists in large quantities in some of the rocky islands off the coast of Peru, where, in the course of ages, it has been formed by the deposit of the excrements of innumerable multitudes of sea fowl, who haunt these localities, especially during the breeding season.

"It forms irregular and limited deposits, which at times attain a depth of fifty or sixty feet, and are excavated like mines of red ochre. Its real origin was well known to the Government of the Incas, and its national importance fully understood. It was made a capital offence to kill the young birds on the guano islands."—*Professor Johnston, Jour. Roy. Ag. Soc.*, vol. ii., p. 103.

It exists, according to M. Humboldt (*Davy's Elem. Ag. Chem.*, 296), in the greatest abundance in some of the small rocky islands of the Pacific Ocean, as at Chinche, Ilo, Iza, and Arica. Even when Humboldt wrote, some twenty years since, fifty vessels were annually loaded with the guano at Chinche alone, each trader carrying from one thousand five hundred to two thousand cubic feet. The guano is found, according to Liebig (*Organic Chem.*, 81), on the surface of these lands in strata of several feet in thickness, and is, in fact, the slowly putrefying excrements of innumerable sea-fowl that remain on them during the breeding season. It is used by the farmers of Peru chiefly as a manure for the maize or Indian corn, and, it is said, sometimes in the small proportion of about 1 cwt. per acre. "The date of the discovery of the guano, and of its introduction as a manure," says Mr. Winderfelt (*Brit. Farm. Mag.*, vol. vi., p. 411), "is unknown, although no doubt exists of its great antiquity. In many parts of America, where the soil is volcanic or sandy, no produce would be obtained without the guano. It has been calculated that from 12,000 to 14,000 cwts. are annually sold in the port of Mollendo for the use of the country round the city of Arequipa. In the province of Taracapa, and in the valleys of Tambo and Victor, the consumption should be something more, as wheat, all kinds of fruit, trees, and plants, with the single exception of the sugar cane, are manured with the guano; which is not the case with the district of Arequipa, where maize and the potato alone require it. In the district of Arequipa 3 cwts. of guano are spread over an extent of five thousand square yards (about an English acre); but in Taracapa and the valleys of Tambo and Victor, 5 cwts. are required. The land thus manured in Arequipa produces 45 for 1 of potatoes, and 35 for 1 of maize; where wheat manured with horse-dung produces only 18."

There are, it appears, three varieties of guano, which bear on the coast of Peru different prices. "The white guano is considered the most valuable, as being fresher and purer. It is found on nearly all the islands along the coast. The red and dark grey are worth 2s. 3d. the cwt.; a higher price is given for the white on account of its greater scarcity. It is sold at the port of Mollendo at

## *Vegetable Manures.*

Purely vegetable manures are not nearly so active and energetic as those of animal origin; but, on the other hand, their effects are more durable. They appear

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3s. 6d. per cwt., and at times, as during the war, it has obtained as high a price as 12s."

In a recent obliging communication (Dec. 29, 1842) from a gentleman who has resided many years on the coast of Peru (Henry Bland, Esq., of Liverpool), he observes, in answer to some questions which I had addressed to him with regard to the uses of the guano, the soils, and the climate of Peru—

"The valleys on the coast of Peru consist chiefly of a light sandy soil. *No rain* falls upon that part of the coast where I have seen guano used. Neither are the dews so copious as to be considered by the Peruvian farmer to be of any importance in promoting vegetation in the valleys.

"On the tops of the coast hills a slight verdure is produced by the dews in the winter season, but it does not remain for more than from one to two months. The land of the valleys is irrigated; but without the limits of irrigation all is a desert, with the exception of the slight vegetation I have alluded to. This is the state of the coast from about 5 degrees to 22 degrees south latitude.

"I do not believe that so small a quantity as 1 cwt. of guano per acre is found sufficient for the soil upon any part of the coast of Peru. In the neighbourhood of Arequipa the first crop is maize (Indian corn). The seed is sown in drills or trenches, and the bunches (three or four plants I call a bunch) come up about two feet apart. When the plants are six or eight inches above ground, a pinch of guano (as much as can be easily held between the thumb and two fingers) is placed around each bunch, and the whole is usually irrigated immediately afterwards. Guano is again applied when the plant is about throwing out its fruits, *a handful* is then applied to each bunch, and irrigation immediately follows. The next succeeding crops, potatoes and wheat, are produced without any further application of manure.

"In the valley of Chancay, distant from Lima about forty miles, a soil which without guano is capable of producing only 15 for 1 of Indian corn, with guano is made to produce 300 for 1. In speaking of guano, the Peruvians say, 'Aunque no sea santo hace milagros.'—Guano, though no saint, works miracles.

"Guano to be *good*, being in some measure soluble in water, can never be found in its most powerful state in any climate where rain falls; and, consequently, any that may be brought from the coast of Peru, taken from without the *limits of dryness*, must be of inferior value compared with that which comes from the Chincha Islands; situated in about 10½ degrees south latitude, and about ten miles distant from the main; and from Paquica, on the coast of Bolivia, in latitude 21 south. Upon these islands, and at Paquica, is the principal deposit of guano. Two or three cargoes of guano from the coast of Chili (where rain is frequent) have found their way into this country, and have, I believe, been sold for Chincha guano, thus injuring both the character of the best guano as a manure, and the importer of the genuine article.

"I may mention a circumstance to show the little estimation in which nitrate of soda, compared with guano, is held by the Peruvian farmer. On the coast of Peru nitrate of soda is produced at a distance of about forty-five miles from Iquique, the port at which the principal part of the nitrate is shipped. For mules, to transport the nitrate from the place where it is made to the port of shipment, the nitrate merchant, who sells for export, depends chiefly upon the farmers who reside in the immediate neighbourhood where the nitrate is produced, and he can only secure their services by having always ready for to produce a more durable humus; but which is not so easily or so promptly absorbed by the suckers of plants. An addition of animal matter, of lime, or of alkalies, tends materially to accelerate their decomposition. A

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them, in the port of Iquique, a return load of guano, which they carry back to manure their farms, after having carried a load of nitrate almost from their own doors to the port of Iquique."

Guano appears, in the state in which it has been lately introduced into this country, to be a fine brown or fawn-coloured powder, emitting a strong marine smell; it blackens when heated, and gives off strong ammoniacal fumes. When nitric acid is mixed with it, uric or lithic acid is produced. It has been analyzed by various chemists. In 1806 an analysis of a very elaborate description was published by MM. Fourcroy and Vanquelin; they found in it a fourth of its weight of uric acid, partly saturated with ammonia and partly with potash; some phosphate of lime and ammonia, and small quantities of sulphate and muriate of potash; a little fatty matter; and a portion of sand. It has been more recently analyzed by Mr. Hennell, of Apothecaries' Hall, who found in guano—

| | Parts. |
|---|---|
| Bone earth | 30·5 |
| Sulphates and muriates | 3 |
| Uric or lithic acid | 15 |
| Carbonate of ammonia | 3 |
| Matters volatile at 212°, consisting chiefly of water and carbonate of ammonia | 12 |
| Other organic matters | 36·5 |
| | 100 |

The composition of guano varies, however, considerably. According to the analysis of MM. Voelckel and Klaproth, the varieties which they examined contained—

| | Voelckel. Parts. | Klaproth. Parts. |
|---|---|---|
| Urate of ammonia | 9 | 16 |
| Oxalate of ammonia | 10·6 | 0·0 |
| Ditto lime | 7 | 12·75 |
| Phosphate of ammonia | 6 | 0·0 |
| Ditto ammonia and magnesia | 2·6 | 0·0 |
| Sulphate of potass | 5·5 | 0·0 |
| Ditto soda | 3·3 | 0·0 |
| Chloride of sodium (common salt) | 0·0 | 0·5 |
| Ditto ammonia | 4·2 | 0·0 |
| Phosphate of lime | 14·3 | 10 |
| Clay and sand | 4·7 | 32 |
| Undetermined organic substances, of which about twelve per cent. is soluble in water, a small quantity of soluble salt of iron, water | 32·53 | 28·75 |

In a few words, it may be regarded as an impure compound of phosphate of lime, of urate of ammonia, and other salts. There is no doubt but that it is a very powerful manure; the very composition of its salts would indicate this fact.

According to the analysis of Professor Johnston, the quantity of sand always present in the imported guano varies from two to eleven per cent; the sand consisting chiefly of mica, quartz, and felspar, the debris of the rocks of the soil that is from time to time ameliorated with purely vegetable manures, preserves its fertility better; it retrieves that richness and succulency which it had lost, in a much more durable manner than it would if ameliorated with animal manures only: this is the reason that land which has become very much impoverished or exhausted recovers itself so much more effectually when suffered to repose, than it does when manured.

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coast of Peru. A specimen, which Professor Johnston examined, he describes as being "of a brownish-red colour; it is evidently a very ancient deposit, and has undergone much decomposition. It consists of a powdery portion mixed with lumps of various sizes. The latter, when broken, exhibit an aggregation of minute crystalline plates, are much richer in ammonia than that which is in powder, and are free from sand and stones. When broken up, however, the lumps speedily lose their crystalline appearance, give off ammonia, even at the ordinary temperature of the atmosphere, and assume the condition of the powdery portion with which they are mixed."

It would appear, from the results of the various trials which have been recently carried on in this country upon the guano, that it is certainly a fertilizer possessing powerful effects; but it is pretty clear that it must be used in larger proportions than was formerly suggested—from 3 to 4 cwts. per acre appear to be the proper proportion. It is also evident, from the trials which I have witnessed, as well as from many whose results have been published, that it should not be applied in immediate contact with the seed. If, therefore, it is applied by the drill, which I believe to be the best mode, it should be applied by a separate coulter, and by the mode adopted in the improved Suffolk drills, by which the manure is deposited in the soil so much deeper and so much in advance of the seed as to allow a portion of the soil to be interposed between the seed and the manure beneath it. Like all other concentrated fertilizers, it is pretty certain that for the most successful development of its powers it requires a considerable supply of moisture, and will, therefore, produce the best results during wet seasons. It is used, it seems, in many situations in Peru, which are immediately afterwards irrigated.

From these facts, and from the general good effects which it has been noticed to produce on grass-lands in St. Helena, and in Lancashire, and other of the most rainy English counties, it is evidently well adapted for a top dressing for meadows, and low situated lands in general. This, too, seems to accord with the opinion of Mr. J. Beadel, a very excellent cultivator and land agent, of Witham, who remarks, in a communication with which he recently favoured me—"I think there can be no doubt as to genuine guano being a most powerful fertilizer; and were I about to use it, I should prefer applying it as a *liquid manure*.

"I am rather inclined to think that most of the top-dressings which we use will succeed better as a stimulant for green crops, and probably on grass-land, than for cereal crops; with me, I have found *wheat* more subject to mildew when so dressed. The straw then is dark and very vigorous, but the kernel does not plump up. It may be that I used too much, and so failed; the appearance was very like corn grown on a dung-hill, rank but not *corney*."

I think also, from my observations, that if the guano is well mixed with three or four times its weight of finely sifted earth, and suffered to remain for some weeks in this state before it is used by the drill or applied broadcast, that its effects would be more considerable, and the sometimes too powerful effects of guano upon the growing crop avoided.—*Johnson on Guano.*

We have already enumerated the vegetable substances which may be used as litter with the greatest advantage; these substances when mixed with the excrements of the animals easily become decomposed, and serve to moderate the rapidity with which the animal manure putrefies.

But there are also other vegetable substances which in their separate states may be applied to the manuring of that soil from whence they have sprung. They may be restored to the land in one of two ways, viz., either accidentally or intentionally.

There cannot be a doubt that all those weeds which are allowed to produce their flowers and then buried by the action of the plough, tend to augment the fertility of the soil. For, although the development of almost every plant is in some measure dependant on the mould or humus contained in the soil, yet numerous experiments serve to prove that plants likewise absorb aeriform substances, and in all probability the constituent parts of decomposed water as well, which they transform into organic matters by means of their own internal mechanism. It may, therefore, be admitted as a fact, that every vegetating plant increases the organic matter and humus of the soil, if it perishes in the same spot in which it originally sprang up. This is one reason that a complete fallow in which a great quantity of grass and weeds spring up after each ploughing, may be regarded as equal to a slight manuring, and that independently of all the other advantages which it produces. The more abundantly and vigorously weeds spring up, and the greener the soil becomes between each ploughing, the more is it benefited. Those fields which produce the greatest quantity of hedge-mustard (*erysimum*) derive most benefit from fallowing, independently of the advantage resulting from the destruction of this weed.

There is not a single vegetable substance, even down to the stubble which most crops leave behind them, which does not restore some portion of mould to the soil. The longer this stubble is, the greater effect does it produce; therefore, where a similar quantity of manure is bestowed on the land, the soil becomes less exhausted in those districts where it is customary to leave the stubble long when the corn is reaped. But it is highly necessary that this stubble should be buried without loss of time, as it appears that it only becomes decomposed when buried in the soil, but that when exposed to the air it dries up and turns to powder. In general the stubble of plants which possess long thick roots and stems deposits a larger portion of vegetable matter in the soil than the stubble of corn-fields; but that which is productive of the most beneficial effects when buried with roots and stems is the stubble of vegetables which have not borne their seed, or become dry and strawy, and which contain a considerable quantity of mucilaginous particles. Hence arises those ameliorating effects attributed to vetches and clover mown while green: these plants shed a portion of their leaves and stems on the soil, and thus enrich it before they are gathered, and generally put forth fresh leaves and shoots previously to being ploughed into the soil.

Nothing tends to improve land more than the turf or accumulation of herbage which is successively formed during a number of years. The thick tissue of the plants and their clusters of roots, the animal matter of the dead worms and insects, the excrements of the cattle which have been pastured—these all combine to render the soil peculiarly fertile and capable of yielding several successive crops without the addition of fresh manure. It is quite an erroneous supposition to attribute this amendment solely to rest, since rest alone could only have been productive of a negative good. The better the condition of a soil when laid down to grass, the more herbage will it be able to produce, and the more will it profit by the term of repose allowed to it; not only on account of its inactivity, but because its productive powers are much greater.

The erroneous opinions which are in general entertained with regard to the effect produced on land by repose, have perhaps given rise to the prejudice in favour of, and in some degree contributed to the maintenance of the custom of only laying down those portions of land to grass which are completely exhausted, in the hope that by so doing they might be restored to their pristine fertility and activity. And it cannot be denied that repose does produce this effect, because no soil is ever so thoroughly impoverished as to be incapable of putting forth some few shoots and sprouts of herbage: but the improvement which results is much more backward, and its effects much weaker than if the land had been in a better condition when abandoned to nature. The more fertile a soil is when laid down to grass, the more leaves and roots and patches of herbage does it put forth, the more worms and insects are engendered, the greater number of cattle are pastured on it, and, consequently, the greater quantity of excrements are voided over it: thus, therefore, the more it abounds in nutritive juices when first laid to grass, in the greater degree will it be benefited by the period of repose.

We bestow a most active and abundant vegetable amendment on a soil when we sow it with plants adapted to its nature, which will flourish and attain the highest state of development; and then when they have begun to flower, either bury them by the action of the plough, or have them eaten of the ground, or trodden in by cattle. This practice is of great antiquity: it was held in high estimation among the Romans, and exists at the present day in Italy. There it is that the amelioration produced by a crop which has been buried while green is the very best that can be bestowed on a soil, and is capable of bestowing on it the utmost degree of fertility of which it is susceptible: indeed, they even prefer it when there is a sufficiency of animal manure. The climate of Italy certainly is more favourable to the success of this practice than ours, because those crops which are intended to ameliorate the soil are not sown until after the harvest, which is more forward there, and because those crops have then more time than they absolutely require to enable them to attain their highest degree of vegetation. Of all the plants used for this purpose, none were so much prized as the *lupinus albus* (white lupine). This plant has from time immemorial been cultivated solely for this purpose, and still continues to be so in the present day; the extreme bitterness both of its seed and stem precludes all possibility of using it as food, either for men or animals.* We have analyzed the white lupine superficially, and mean to institute a more minute examination of it, and we found that it contained a considerable portion of mucilage, which may perhaps explain its peculiar adaptation for the improvement of land. Sismondi in his "Agriculture of Tuscany," tells us, "that the seed of the lupine, after having been deprived of its vitality, is buried at the root of olive trees in order to manure them." We have only to institute a few experiments, and we shall soon discover whether or not this plant is sufficiently distinguished by its fertilizing and ameliorating properties to make it worth our pains to cultivate it. It is well known to all florists and gardeners that it thrives exceedingly well in this climate. I cannot, however, at present determine whether, if sown after a crop of rye, it would become sufficiently developed to be buried with advantage; but we have several other plants which are equally proper for the purpose, if not more so.

The following are the properties which ought to be united by those plants which are cultivated for the purpose of being buried as vegetable manure.

(*a*). The plant chosen ought to be one adapted to the texture, qualities, humidity, and situation of the land on which it is to be sown, in order that, so far from vegetating slowly, it may shoot up and flourish with all possible rapidity.

(*b*). The seed must neither be expensive nor scarce, or it must be of such a nature that a small quantity of seed will sow a considerable extent of land.

(*c*). This plant must attain its full vigour and development in the shortest possible space of time, in order that the requisite number of ploughings may be bestowed on the fallow, if the crop be sown on fallow land, or that it may succeed the harvest of some other crop, and attain its development that same year.

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* The Italians have a method of preparing the lupine which deprives it of its bitterness; I have frequently seen it bought and eaten by the peasantry, who appear to like it very well.—FRENCH TRANS.

(*d*). It must be well adapted for the purpose of keeping the soil loose, must penetrate deeply into it by means of its roots, and cover it with its leaves.

(*e*). It must contain a considerable portion of mucilage, or of some other vegeto-animal substance, which is analogous to animal matter.

(*f*). It must be disposed to putrescence.

There is no plant that unites all these qualities in so eminent a degree as the *spergula arvensis* (corn spurry); various trials with regard to its fitness for this purpose have been made, almost all of which have turned out well. (*Annals of Agriculture of Lower Saxony, fourth year, section* 1*st, A.*) Previously to ploughing this plant into the soil, cattle may be allowed to pasture slightly upon it; but then they must be suffered to remain there during the night, if we would not take away a considerable portion of the advantages which might otherwise be derived from this practice.

Various other plants are used for this purpose; *those which bear oleaginous seeds*, as *rape*, &c., are peculiarly well adapted for it; several vegetables appertaining to the class diadelphia, as *peas, vetches*, and *beans*. It is chiefly in England that vegetables are used for this purpose; even there, these crops are often on the ground previously to being covered by the plough; and in order to effect this object, all kinds of cattle, and especially pigs, are suffered to feed on them. These last-named animals fatten rapidly there, and thus contribute towards paying for the seed which would otherwise become too expensive.

The same use is occasionally made of buck-wheat; when this plant is green it furnishes a very nutritive fodder.

Frederick the Great, himself, relates that radishes have been sown chiefly with a view to this purpose; and my estimable friend, Harmstadt, who relates various experiments on this subject, assures us that *beet*-root, mixed with different substances, produces a very active species of manure. (*Annals of Agricultural Chemistry, by Hermbstadt,* vol. i. A.)

We must not overlook a practice which has been preserved in a manner so marked and consistent in all those places where it is known; on the contrary, I think that it deserves to be analyzed with all possible attention, and to be inquired into in all its bearings. At first sight, we cannot help fancying that there is a degree of extravagance in causing a crop which might be mown, and consumed in the stable by animals, to be crushed by the roll, or trodden down by cattle. Many persons are of opinion that this kind of manure will be equally as beneficial to the land if the crop is made to pass through the bodies of the animals, as it would be if the plants were buried at once; and they are quite right. But the extent of land which can be sown with crops of this nature will always be so great as to produce far more fodder than is necessary to supply the wants of the cattle, of which a certain limited number is usually kept; and it frequently happens that it is not possible to procure a sufficient number of labourers to gather the whole of these crops. Nor is this all: the Italians have observed that some kinds of lands are materially benefited by occasionally receiving an amendment composed solely of vegetable matters, or, as they term it, a *refreshing amelioration.*

Many authors have recommended this practice for the amelioration of distant or detached portions of land only, or of such as have been exhausted, or are newly brought into cultivation; but it would not benefit impoverished soils much, because the plants sown on them for the purpose of being turned into the ground as manure, would vegetate too feebly. Land must contain succulent matter in order to be able to produce them with any degree of success; therefore, this species of manure is better calculated to preserve the fertility of a soil than to lay the foundation of it, and in all probability it is on that account that it has hitherto been so little used among us.

If we come to regard a field well covered with a thick crop of vegetables, we may easily conceive what may be expected from such a quantity of stems and leaves when buried in the soil for the purpose of manuring it.

All kinds of vegetable refuse may be used as manure, if collected together and decomposed by the admixture of a small quantity of animal substances or lime.

The sweepings of the kitchen, weeds, wood, rotten saw-dust, soot, tanner's spent bark, or oak bark, from which the greater part of the astringent principle has been extracted, may all be converted into manure. Those vegetable substances which yield a considerable portion of potassa, on being burned, are eminently adapted for the amendment of land; of this number are the stems of tobacco plants, maize, straw, &c.; but these should only be thus employed when no other use can be made of them.

The haulm of potatoes also possesses the means of ameliorating land in a particularly high degree; but in order that it may putrefy rapidly, it must be gathered together or mixed with dung while in a green state. An attempt has been made to form a kind of compost with potato haulm, turf, and a little lime, which is said to have produced excellent effects. No insignificant quantity of this substance will be yielded by an acre of potatoes. If the haulm is left on the ground and subsequently ploughed in, it becomes gradually decomposed; this circumstance may serve to explain the reason of some persons having believed that potatoes are not a very exhausting crop. The process of decomposition, however, progresses very slowly, and retards the sowings a little.

There are also several other very useful plants, the stems and stalks of which shoot up to a considerable height, and which, independent of their actual produce, are capable of yielding a large quantity of mould, a circumstance which doubtless ought to be taken into consideration in making choice of one kind of product rather than another; of this number is the *helianthus annuus* (annual sunflower), and the *helianthus tuberosus* (Jerusalem artichoke).

Sea-weeds and pond-weeds may likewise be entered in the class of vegetable substances which yield an active and energetic manure; among the former we may particularly notice the variety of the *fuci*, and among the latter the *chàra vulgaris* (common chara), which is always covered with a calcareous mucilage; but if we would derive all the advantages from these plants which they are capable of yielding, we must, in the first place, cause them to undergo decomposition either by themselves or mixed with a little animal dung.

The mud which is found at the bottom of rivers, ponds, and other places in which stagnant water has remained for any length of time, and the scourings of old ditches, are matters which ought to be included in the class of vegetable manures; for although this mud is sometimes mixed with animal matter, and likewise contains a great proportion of those earths of which the neighbouring soils are composed, still the vegetable substances predominate in quality if not in quantity. This substance may in general be assimilated to vegetable manure; that is to say, it is less energetic and stimulating than animal manure, but more durable in its effects, and richer in saccharine and extractive matter. It is therefore termed "refreshing manure," and the most durable effects are attributed to it.

In the section on Agronomy, we have already spoken of the different kinds of earth, and of their nature, and have carefully distinguished those which are sour or acid from those which are devoid of acidity.

It is very advantageous to an agriculturist to discover such a store of fertilizing substances in his own estate. However great may be the difficulties and expenses attendant on the extraction and transport of such a treasure to the fields, they will always be fully remunerated, and those who have it in their power to advance the requisite outlay will find themselves amply repaid. I must confess, however, that these expenses are always very great, and that they seldom yield much profit during the first years of application.

The principal inconvenience attendant on the extraction of mud or mould arises from the difficulty in clearing it from water, for it is seldom sufficiently dry when first extracted. This may occasionally be obviated by digging furrows for the purpose of carrying off the moisture; but, in general, the ditches or excavations in which the mould is found are surrounded by elevations, so that it is impossible to find any outlet through which it may escape. In this case, recourse must be had to machines for the purpose of drawing up the water by pumps, or to some other hydraulic engines. This operation must either be performed in the summer, or during the hard frosts of winter; it is scarcely possible to effect it in the spring and autumn, because the labourers, having to stand in so much wet, would be unable to bear the cold. In the midst of summer this mud is apt to exhale pestilential vapours, which are calculated to engender fever and various other diseases, not only in the labourers employed in the operation, but also in the inhabitants of the vicinity. This is especially the case when the mud has lain under water for a considerable period. It is, therefore, generally preferable to execute this operation in the winter season, provided that care has been taken during the autumn to divest the water which might otherwise prove an obstacle. This operation may be rendered very expensive, by the difficulty which will be experienced in cleaving and detaching the mud when it is frozen hard, as well as by the necessity of carting and transporting the ice with which the mud is firmly united.

This kind of manure should never be conveyed to the soil for which it is intended until it is perfectly dry. When in a moist state, it must first be laid in some place where it may be deprived of the moisture, and left there until every particle of water is evaporated; because its weight and volume is thus considerably diminished, and the carriage of it rendered less difficult. This kind of manure is usually conveyed from place to place by means of tumbrels or dung-carts, or in large wheel-barrows, the former being drawn by one horse. Local circumstances alone can enable us to decide which of these two vehicles are most expedient to be used. If the mud has only to be carried a little way, wheel-barrows will certainly be most proper; but where it has to be conveyed a considerable distance, tumbrels will be least expensive. These latter cannot, however, be used when the ground over which the mud has to be conveyed is of a marshy nature; in that case a pathway, composed of boards, must be made.

This operation is generally executed by the task or job. Where this is the case, those who undertake it reckon their work by cubic measure or by the cart-load. Nothing definite can be said with respect to the usual price of such labour, excepting that it ought to be better paid than almost any other, because it is the most unhealthy and laborious of all agricultural operations. Besides, it is absolutely necessary that the labourers employed should have some little brandy to drink.

If the mud is completely putrefied, it should be put in little heaps, in order that it may dry more quickly, and that a greater extent of surface may be exposed to the influence of the atmosphere. But if it still contains a considerable quantity of undecomposed vegetable matter, of moss, or aquatic plants, it should be formed into large heaps when dry, in order that it may thus become heated, enter into fermentation, and the vegetable matter be thoroughly putrefied. This putrefaction, or decomposition, will be greatly accelerated if a little calcined lime or fresh horse-dung be mixed with the mud.

These additions are particularly necessary to mud which contains an acid quality, even should it be completely decomposed. It is often advisable to postpone the addition of these substances until the matter in question shall have been carried to the land on which it is to be used; and this is especially the case when, instead of being spread over it at once, it is left there in heaps, as the double carriage of the lime, ashes, &c., is thus saved. This remark is not, however, applicable to mud which dries quickly; for then, instead of making it into heaps, it is carried at once from the place whence it is extracted, to the land over which it is to be spread.

If we would have this mud produce prompt and immediate effects, we must add to it either animal manure, alkalies, or alkaline substances, which will increase its solubility; but it is only necessary to effect this mixture in the heap, when the humus which it contains is of an acid nature. After the mud has been spread over the soil, and these substances have also been added, the mixture may be effected by means of shallow ploughings, and repeated and careful harrowings. An admixture of marl, especially if it contains a considerable portion of lime, that of calcined lime, or animal dung, with the mud used for the amelioration of land, has always appeared to be productive of very beneficial effects. It is not necessary that any very considerable quantity of manure should be applied to land ameliorated with this substance; one half of the usual proportion will be quite sufficient: if more is added, the corn crops which succeed to an amelioration of this nature will inevitably be laid. But if the mud is turned in by a ploughing, and no portion of manure is added, its effects will not then be perceptible during the first crop, whatever they may be in the second; and should this substance be at all of an acid nature, it will even prove injurious. Nevertheless, sooner or later the advantages resulting from it will become evident. They generally begin to appear about the third year, and then the effects produced are much more durable.

The quantity of this substance which is said to have been, or which ought to be, applied to the amelioration of a field varies very much: in some places a load of sixteen cubic feet is allowed for a square perch of land, and, consequently, one hundred and eighty loads per acre; while, in other places, only twenty such loads are allowed for an acre of land. Some persons affirm that it ought never to be spread over the ground in less than one inch in thickness, while others maintain that the thickness on the land ought never to exceed a quarter of an inch. But this depends in a great measure upon the composition and nature of this manure, since it will cause a considerable difference in the effects produced by it, whether this substance contains a great proportion of those earths of which the soil to which it is applied is composed, or whether it contains those of an opposite nature, or consists chiefly of vegetable mould, properly so called. It not unfrequently happens that a perfectly black mud will only contain eight or ten parts in a hundred of humus, and all the rest earth; and, nevertheless, its addition to the land will be productive of beneficial effects, especially when the kind of earth which it contains is of a totally opposite nature to that of which the soil to which it is applied is composed. Thus, for example, pure clay, refined by water, is beneficial and efficacious when applied to a sandy soil; but if the mud were chiefly composed of silicious earth, it would not be productive of any more effect than that resulting from the humus contained in it. In the latter case, therefore, a large quantity must be applied, if we would effect any sensible amelioration in the soil. After having chemically analyzed the mud, the quantity of it must be calculated which it will be necessary to apply to a certain portion of land in order that each square foot, which being six inches deep, is equal to half a cubic foot and weighs about fifty pounds, shall receive at least a pound of pure humus; consequently, should this substance not contain more than ten parts in a hundred of humus, ten pounds of it must be applied to every square foot. This proportion will raise the quantity to be applied to two hundred and fifty-nine thousand pounds per acre; which, supposing each load to contain sixteen quintals, will make one hundred and sixty-two loads per acre. The more humus this substance contains, the smaller proportion of it will be requisite to ameliorate a piece of land. I do not mean to assert that a small quantity of this mud will not be productive of any effect, but merely that a sensible or durable effect must not be expected from any amelioration of this nature in which less than two parts in a hundred are added to the soil.

The weight of this mud is also susceptible of great variation; it is lighter in proportion as it contains a greater quantity of humus, and especially when it comprises substances which have not become thoroughly decomposed; the strength of a load must not, therefore, be estimated by measure, but rather by weight.

It is of very great moment that this substance should be carefully mixed with the soil, and that this mixture should be effected at once, or, at any rate, before the termination of the year in which the manure is transported to the land. If it is suffered to lie there long without being incorporated in the soil, it agglomerates, and forms itself into clods, which are a considerable time before they fall to powder and become equally divided, especially in coherent and tenacious soils; and, until it is thoroughly divided and incorporated, it produces little or no effect. It will therefore be better never to attempt to sow any crop after the first or even the second ploughing which succeeds to the application of an amelioration of this nature, but to suffer the land to lie fallow, during which time a perfect incorporation of the mud with every portion of the soil may be effected by means of shallow and repeated ploughings, and careful harrowings. This is particularly necessary where the mud contains a considerable portion of earth, properly so called. The mud which is obtained from marshes or bogs, and which is not entirely decomposed, may be suffered to remain on the soil without producing any inconvenience, because, during its decomposition, it divides and pulverizes without difficulty. One of my correspondents informs me that he has found it peculiarly advantageous to sow, on land thus ameliorated, some vegetable, the growth of which is very rapid, and which is intended to be ploughed in as manure: common spurry has appeared to him to be peculiarly adapted for this purpose.

Peat is a substance which may also be employed for the amelioration of land, and especially of light friable soils; but when this substance contains acid, or what is still worse, bitumen, it must be made into heaps, and suffered to remain there for a considerable period, mixed either with calcined lime, or strawy stable dung, or, lastly, with very fine sand, which many persons assert is capable of destroying all baneful properties. These peat heaps must be kept moderately moist; and the best and most advantageous way of keeping up the requisite degree of humidity is to water them with urine or dung-water. Great advantages have frequently been derived from forming heaps of alternate layers of peat and calcareous marl; they must be very frequently stirred, and turned over.*

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* Mr. Dixon, of Hathershaw, in Lancashire, in his Prize Essay, thus describes the result of his long experience:—"My farm is a strong retentive soil, on a substratum of ferruginous clay. My object was to improve its texture at the least cost. For this purpose we carted great quantities of fine sawdust and peat earth, or bog; we had so far to go for the latter, that two horses would fetch little more than three tons in one day; one horse would fetch three cart-loads of sawdust in the same time. Having brought great quantities of both peat and sawdust into my farm-yard, I laid out, for the bottom of a compost heap, a space of considerable dimensions, and about three feet in depth; three-fourths of this bottom was peat, the rest sawdust; on this we conveyed, *daily*, the dung from the cattle-sheds; the urine, also, is conducted through channels to wells for its reception (one on each side of the compost heap); common water is entirely prevented from mixing with it. Every second day the urine so collected is thrown over the whole mass with a scoop, and at the same time we regulate the accumulated dung. This being continued for a week, another layer, nine inches or a foot thick, of peat and sawdust (and frequently peat without sawdust) is wheeled on the accumulated heap. These matters are continuously added to each other during winter; and in addition, once in every week, never less than 25 cwt., more frequently 50 cwt., of night-soil and urine; the latter are always laid next above the peat or bog earth, as we think it accelerates their decomposition. It is, perhaps, proper here to state, that the peat is dug and exposed to the alternations of the weather for several months before it is brought to the heap for admixture: by this it loses much of its moisture. Some years' experience has convinced me of the impropriety of using recently dug peat: used in the manner I recommend, it is superior and more convenient on every account; very much lighter to cart to the farm-yard, or any other situation where it is wanted; and so convinced am I of its utility in composts for every description of soil, except that of its own character, that wherever it can be laid down on a farm at less than 4s. per ton, I should recommend every agriculturist and horticulturist that can command it, even at the cost here stated, to give it a fair trial. So attractive and retentive of

If peat-dust has remained in heaps for a long time, it may be used as manure without the addition of any mixture, and is peculiarly adapted for the amelioration of argillaceous and tenacious soils.

In the neighbourhood of turf pits this proceeding will be most profitable, on account of the trifling expense which it will cost.

Lastly, coal and bituminous earth, impregnated with sulphate of iron, must not be omitted in the enumeration of that class of manures which are of a vegetable origin; this substance has been employed with great success, and for the first time on a large scale, in the amendment of land at Oppelsdorf in the neighbourhood of Zittau. But as the principal part of the success attendant on it is mainly attributable to the sulphate of iron, we shall recur to this subject when speaking of those manures which are derived from saline substances.

We shall reserve our remarks on ashes as a manure to the same place, although this substance owes its existence to vegetable matters.

### *Mineral Manures.*

As an excessive proportion of some one of the elementary earths, and even of humus, is liable to prove injurious to the soil, by deranging the equilibrium of its physical properties, destroying its consistence, or its disposition to retain moisture, &c., attempts have been made to remedy this evil by the application of another earth of diametrically opposite properties. This practice may be termed the *physical amelioration* of the soil, in order to distinguish it from the *chemical amelioration*, which comprises not only the use of manures properly so called, that is to say, of the aliments destined for the nutrition of vegetables, but also of the substances which

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moisture is peat, that if liberally applied to an arid, sandy soil, that soil does not burn in a dry season; and it so much improves the texture and increases the produce of an obdurate clay soil, if in other respects rightly cultivated, that actual experience alone can fairly determine its value."—*Jour. Eng. Ag. Soc.*, vol. i., p. 135.

develop those aliments, and prepare them for being taken up by the roots of plants.

This amelioration of the physical qualities of the soil, by the addition of an earth which is opposite in its nature to those composing the land which it is intended to ameliorate, is undoubtedly within the list of practicable undertakings, but there are very few cases in which it can be effected with any degree of advantage. It is hardly possible to correct the defects of an argillaceous and tenacious soil with sand, or those of a sandy soil with clay, excepting in those cases in which the kind of earth necessary to effect the required amelioration is found in the inferior stratum of the soil to which it is to be applied. There is no doubt that in such cases the necessary amelioration may be effected by means of deep ploughings; so directed, however, as not to bring too thick a layer of the virgin earth to the surface. In general, the new earth can only be raised from the bed on which it rests by means of deep trenches, or excavations, from which it is dug and thrown up by the shovel, and then spread over the surface; while that earth which was formerly on the top is cast into these excavations to fill them up.

If the ameliorating earth has to be procured from any considerable distance, or to be raised from a great depth in the ground, these operations become so expensive as only to be practicable in some few localities and cases; for, in order to effect such an amelioration in the soil, or, in other words, to alter the nature of the layer of vegetable mould, a very large quantity of earth will generally be requisite; so great, indeed, that the soil will often be bought too dearly. It is therefore necessary to calculate what is the relation which exists between the constituent parts of the earth which is to be procured, and those of the land which we wish to ameliorate; and, consequently, how much of the former will be requisite to effect a proper and advantageous mixture throughout, at least, a depth of eight inches of the vegetable mould of the latter. We shall thus be enabled to ascertain what will be the cubic measure requisite for a certain given extent of space; and to calculate, with reference to all the local circumstances of the case, what will be the expenses of raising, loading, carrying, spreading, &c.: a rough estimate of these things may be made at first, which we can subsequently reduce, at our leisure, to a more definite calculation. To this must be added the consideration, that it is exceedingly difficult to effect a thorough combination of sand and clay, unless these substances are of a marly nature, or contain calcareous particles: where such is not the case, these earths cannot be sufficiently divided to incorporate completely with each other.

If we convey sand to an argillaceous soil, or clay to a silicious soil, the mixture cannot be effected without repeated ploughings, the two or three first of which must be as superficial as possible, and the others gradually deeper; to these must succeed harrowings, and the clods must be broken by the action of the roller, or by mallets. The period selected for the performance of all these operations must be when the clods have attained the degree of dryness in which they can be most easily divided and broken by these proceedings: this generally occurs about the middle of summer; but it is rarely possible to complete the operation in the course of one summer. The division of the earth may be accelerated by mixing dung or calcined lime with it, or by sowing it with such plants as have roots sufficiently strong to penetrate the clods, and which may subsequently be ploughed into the soil as manure. When the ameliorating earth has not been thoroughly blended and incorporated with the soil, so far from improving, it rather tends to deteriorate the land for a very considerable period, for there are very few plants that will not be injured by their roots coming in contact with a soil of so heterogeneous a nature. When we read in the works of ancient authors, or hear accounts of the success with which ameliorations of this nature have been attended, we may generally feel convinced that the earth which was applied was a marl of a more or less calcareous nature. It was not long ago that the operation of marling land was designated in Holstein, ameliorating it with earth; and the persons who performed it, persisted in asserting that it was clay they applied, because at that time marl was scarcely known or recognised there. No really ameliorating effect can be expected from clay until it has been exposed for several years to the influences of the atmosphere, as is the case with that which has formed the sides of ditches, dykes, &c., or of which walls have been constructed. Clay which has been thus exposed to the air is more easily divided, and blends with the soil more intimately.

The physical condition of clayey or argillaceous soils is ameliorated in a very durable manner by paring and burning them, because this operation renders their texture more open and porous, and deprives them of their too great adherence for water; their fragments are thus rendered less coherent, and, in point of physical properties, somewhat similar to sand. Besides, in all probability, this operation likewise produces a chemical effect which has not as yet been sufficiently explained.

Silicious earth is that which is most frequently and advantageously used in the amelioration of rich soils which are deficient in consistency, and disposed to retain moisture. The sand which is conveyed to soils of this texture, gradually penetrates into the mould and fills up its spongy texture; it must, therefore, be spread over the surface and there left. It is never so efficacious as when it is spread over land which is covered with grass; it then renders the vegetation of plants growing there more vigorous, and produces effects equal to a very active manure. Experiments without number which have been made on lands of this kind, prove beyond a shadow of doubt, that sand produces a more beneficial effect than even the most energetic manure: in fact, manure would be rather injurious than otherwise to soils of the kind of which we are now speaking.

The lime which some soils naturally contain has also a considerable influence on their physical properties. Nevertheless, when we add this substance to a soil, we think only of the chemical effect, because lime can seldom if ever be employed in sufficiently large quantities to produce any sensible alteration in the consistency of the soil.

Both the chemical action of lime and the effect which it produces as a manure, appear to be of two kinds. On one hand, it acts on the humus by accelerating its decomposition, and rendering it soluble, and thus fit to enter the minute fibres of the roots of plants. This is the reason that an amelioration composed of lime is the more efficacious the richer the soil is in humus, and that its action is the more sensible in proportion as this humus is of an insoluble nature. Lime deprives sour humus of its acidity, and renders it fertilizing. But, on the other hand, there is every probability that by means of its carbonic acid, lime also produces some other effect, and furnishes the plants with some actual nutritive matter. The roots of certain vegetables in particular appear to have the faculty of depriving lime of its carbonic acid, which it immediately re-absorbs in equal proportion from the atmosphere with which it comes in contact. It cannot be denied that an amelioration of lime invariably produces some effect, even on land which contains a very small quantity of humus, and that a repetition of this amendment is never without its effects; although they are, of course, very far inferior to what they might have been if the soil had contained more humus, or had been manured with vegetable or animal matter capable of producing that substance. Besides, every one must be aware, that lime communicates a peculiar degree of vigour to some plants, and that the roots of these can even penetrate rough lime-stone, and in a manner decompose it. This remark is particularly applicable to sainfoin, the tap-root of which penetrates from ten to twenty feet deep into calcareous stones, and there puts forth clusters of lateral roots which render the stone loose and friable all around them. The deeper the roots of this plant penetrate, the more vigorously does it shoot, even on calcareous rocks or stony places which are only covered by a very thin layer of poor soil.

Lime which has been calcined and deprived of its carbonic acid is much better adapted for the amelioration of land, and far more efficacious than carbonate of lime. In its former state, it contributes infinitely more to the decomposition of the substances with which it is united, and acts far more efficaciously on organic matter than it does in the latter. But we must admit that its increased efficacy arises from another cause. It very soon reabsorbs equally as much carbonic acid from the atmosphere as it lost during the process of calcination, especially when, after having been thus reduced to powder, it is mixed with the superior layer of the soil. But the carbonic acid which it has thus recently regained is not in general so intimately combined with the lime as not to be easily absorbed by any plant the roots of which come in contact with it. The lime continues to attract fresh portions of this substance, and thus a permanent communication of carbonic acid is established between the lime, the roots of the plants, and the atmosphere. This may serve to explain the reason that even calcareous soils may be remarkably fertilized by the addition of lime; and that a sensible effect is produced by an addition of this substance, even when the soil already evidently contains a great quantity of it which has been accumulated there by former amendments.

On no soils are the effects of lime so beneficial as on those which contain a great quantity of sour humus prejudicial to vegetation, or on those which have been supplied more or less abundantly with animal manure for a considerable period without receiving an application of lime, or of some other substance of a similar nature. In the latter case, it is frequently much more efficacious than an amelioration of stable manure would be; but it soon impoverishes the soil so much that in a very few years it becomes indispensably necessary to manure it abundantly with rich animal or vegetable matters. As some portion of humus, although in all probability of an insoluble nature, always remains in arable land even when it appears to be most exhausted, it of course follows that an application of lime will always be productive of very marked effects, even on the poorest soils, because it will call into action all the nutritive particles which they contain. A second amendment of a similar nature bestowed shortly after the first will be productive of some, although in general of much less benefit; and the effect of each subsequent amelioration of this nature will be progressively diminished unless the soil receives an additional supply of humus. The effects of lime are far more marked on some crops than they are on others: various observations have given rise to the opinion that it is more efficacious when applied to spring corn than to autumnal crops; and that it is peculiarly favourable to vegetables, and also to clover and grasses.

Argillaceous soils are better able to bear repeated ameliorations of lime than those of a sandy nature; because, in the first place, the physical action of this substance tends to loosen the texture of the land; and in the second place, its chemical action lessens the disposition which all clays have to retain humus. When marshes or bogs have been drained and are brought into cultivation, they are capable of bearing repeated and abundant ameliorations of lime, because they always contain a variety of substances susceptible of decomposition, and on which the lime can exercise its solvent influence. The effect produced by lime on land of this nature is much more beneficial and durable than that of any other manure.

On the other hand, repeated ameliorations of lime will soon totally exhaust and impoverish poor and sandy soils, and reduce them to absolute sterility, even though each separate application seems to be productive of some good effect. If the lime is unable to find any organic matter on which to act, or does not meet with clay—an earth with which it has in all probability a disposition to combine, and with which it forms marl—it then unites with the sand and hardens into a kind of mortar, which cannot be dissolved without difficulty. When such soils have been too frequently and abundantly manured with lime, the action of the plough brings an immense number of pieces of hard mortar to the surface, which are with difficulty divided. Wherever this is the case, the land must receive repeated manurings before it will again be capable of bearing good crops. The truth of this statement has lately been demonstrated on several estates in Silesia, and occurrences of a similar nature have been remarked in those counties of England in which the triennial rotation with a fallow is practised, and where few cattle are kept, and which possess an abundance of lime.

In general, lime is not used until it has been calcined; that is to say, until all the carbonic acid is disengaged; either because it is then productive of the most sensible effects, or because it is only when in this state that it falls to powder and can be intimately combined with the layer of vegetable earth. On this account, the pulverization of calcined lime is expedited as much as possible, and they hasten to mix it with the soil or with those organic matters which are to be used as manure.

There are two ways of effecting the mixture of lime with the soil. The first consists in placing the unslaked lime in the vicinity of some spot well provided with water, and then throwing a sufficient quantity of that fluid on it to reduce it to powder, but not enough to form it into a paste. After the lime has been thus watered, it must be stirred up, and those lumps which still remain, taken out to be moistened again, and thus reduced to powder. During this operation the lime regains its water of crystalization which it had lost during the process of calcination; but it absorbs very little carbonic acid, and, consequently, preserves its causticity. In this state it acts most energetically, and is best adapted for the purpose of breaking down and destroying the texture and organization of all undecomposed vegetable and animal matter contained in the soil, as insects, the fibres of plants, and even the seeds of some weeds, all of which it dissolves and transforms into a very fertilizing mould. When lime is thus powdered, it must be conveyed to the fields without loss of time and spread over the soil with shovels. The land should have been previously ploughed. As the dust of lime is both disagreeable and injurious, care must be taken that the labourers employed in spreading it, and the teams that have brought it to the fields, shall stand to the wind. In those places where lime is much used for the purpose of ameliorating land, cylinders turning on wheels, somewhat similar to those attached to drill ploughs, are adjusted to the carts used in this operation; and the pulverized lime is thus equally spread over the soil.

The second mode of proceeding, and that which is in most common use, consists in conveying the lime to the land to which it is to be applied, and there dividing it into little heaps, each containing about a bushel, and situated at suitable distances from one another. After these heaps are formed, they are covered with shovelfuls of earth taken from the ground around them, and little furrows or gutters are made down the surface to admit the water running off. When it is supposed that the lime is almost or quite divided, a shovel is introduced: if it meets with any lumps, the heap is made up afresh, and again covered with earth. There is no doubt that this practice of covering the lime originated in an erroneous idea that that substance lost some volatile portions by exposure to the atmosphere: but this layer of earth is really useful; for, without such a protection in rainy weather, a crust would be formed over the heaps, which would not only prevent the water from penetrating into them, but would be with difficulty powdered, and almost always remain lumpy.

A third way of preparing lime for being spread over the ground, consists in forming it into large heaps with turf or peaty earth, when these substances can be procured in the immediate vicinity. These heaps should be made near ditches or trenches dug for the purpose of carrying off water, or of declivities or flat surfaces covered with reeds, and which are about to be brought into cultivation. The lime is suffered to remain there until it is quite pulverized, and has decomposed the turf with which it is united: the heap is then repeatedly turned over and stirred. The lime thus combines very advantageously with the earth and humus. This compost, which is often so easily prepared, is productive of the most excellent effects. Lime is also occasionally made into heaps with marshy peat, or with mould which contains a great quantity of undecomposed vegetable substances.

It is indispensable that the lime should be intimately and completely blended and incorporated with the soil, so that every particle of the former substance shall come in contact with some particle of the latter and act upon it. Unless this circumstance is carefully attended to, the ameliorating effects of the lime will be very trifling; the greatest possible care and circumspection should therefore be bestowed on this point. Even when lime has been spread over a soil that has been already fallowed and harrowed, the land must be harrowed once more during dry weather, and then ploughed with as shallow a furrow as possible, in order to bury the lime. The best way is to make use of the extirpator, which effectually combines the lime with the soil. The land must receive at least four separate operations of tillage, including those appertaining to the sowings, with the plough and the harrow, or with the extirpator; and all must be performed during dry weather. It is, therefore, indispensably necessary that a dead fallow should be given to land which is ameliorated with lime. It is chiefly from this circumstance that lime produces the effect attributed to it, namely, the destruction of those weeds with which the soil is infested. But if we bestow an amelioration of this nature, without at the same time bestowing all those operations of tillage which this amelioration requires, we have no right to expect the advantages which we might otherwise derive. If too small a quantity of lime is employed, it is not productive of any effect; while on the other hand, if it is applied too profusely, it is injurious, because it then becomes transformed into heaps of mortar and gathers into lumps. When buried by one deep ploughing, it forms a calcareous crust beneath the layer of mould turned over by the action of the plough, which crust so much impedes the progress of that instrument, the layer of vegetable mould becomes sensibly decreased. This is frequently found to be the case in countries where lime is very cheap, and where it is used too profusely.

There are various opinions with regard to the quantity of lime which ought to be applied to different soils in order to effect their amelioration. The smallest proportion which has ever been used is sixteen bushels per acre; but I have seen and heard of this quantity being increased to one hundred and fifty bushels, especially on newly-tilled soils. English agriculturists, I believe, apply even more than that quantity. The quantity used ought to depend upon the quality of the lime; that is to say, upon its purity, or upon the quantity of sand or clay that is mixed with it. If the calculation is made according to size or measure, that will be influenced by its compactness at the time of being measured. Besides, the nature of the soil ought also to influence the proportion, since an argillaceous soil which contains a great quantity of undecomposed vegetable matter, or which is of a marshy nature, although actually dry, can bear a considerable application of lime, and will profit by it; whereas a sandy, loamy soil would be injured by so large a quantity. Lime is not productive of any effect on damp, wet land. Lastly, we must carefully distinguish between the application of lime which takes place once only, and that which is alternated regularly with stable manure. The former is only used in order to effect that permanent and durable amendment of the soil which may be expected from lime if applied in the manner and under the conditions which we have prescribed; the latter, on the contrary, is intended to maintain it in fertility. The quantity of lime used to attain the first of these two objects ought to be very considerable, while that which suffices for the latter purpose must be small and always proportionate to the quantity of manure which is applied to the land; for in the latter case, it is customary to alternate every three or six years between the use of stable manure and that of lime. There are, however, some countries where lime is applied regularly every third year; that is to say, at every fallow it is applied three or four times in succession before it is again supplied with stable manure. But this course of proceeding exhausts and impoverishes the land to the greatest possible degree.

The most various and contradictory opinions have been put forth with respect to the advantages or disadvantages attendant on the use of lime as a manure, and we can only find our way out of this labyrinth of conflicting statements by means of a theory based upon solid foundations; with the assistance of such a theory, all that at first sight appears problematical with regard to the subject, will be speedily elucidated. Lime, especially when it has recently been calcined, or is, in other words, what we call quicklime, absorbs the carbonic acid which is contained in the atmosphere which surrounds it, and subsequently communicating it to the plants, doubtless furnishes them with some nourishment; but this nutrition is very inconsiderable: the property to which it owes the chief power in promoting vegetation is the faculty of decomposing the humus and inert vegetable or animal substances which it meets with in the soil, and transforming them into nutritive juices adapted to the nature of plants. Hence arise the wonderful effects which it produces when it encounters a great quantity of these substances. Besides, when properly employed, it contributes greatly towards the destruction of weeds. Hence, we see as rich crops derived from a first, and sometimes from a second application of lime as would have been produced had the land been abundantly manured with stable dung. Many persons who have not rightly comprehended the cause of the effects produced by lime, prefer it to manure, and have believed in the possibility of doing entirely without the latter; but the total exhaustion of the soil which such a course of proceeding must sooner or later produce, caused them to fly to the opposite extreme, and to regard the use of lime as an application in the highest possible degree prejudicial and dangerous. An enlightened and scientific agriculturist will soon perceive that the use of lime can never supersede that of dung, but that it renders this kind of manure more energetic in its action. Thus, he will profit by the increased fertility which lime bestows on the first crop which succeeds the application of it, and will procure as much as possible of those substances which are adapted for the production of dung, in order to restore to the land in the shape of stable manure that substance of which it has been deprived by the lime forcing and increasing the vegetation of the crops to which it was applied. He will likewise know when lime will be beneficial and when injurious; and, if he acts with moderation, will be able to employ lime with much advantage in cases where many persons would be afraid to use it.

The propriety of using lime in a great measure depends upon the cost and upon the expenses which will be incurred by the use of it, both of which circumstances are subject to great variation, and depend on locality. When it does not cost more than ten or twelve rix-dollars to bestow a winspel of lime on land, which is the quantity usually applied to an acre, the beneficial effects attending this amelioration will balance the outlay attending it, especially if the land has previously been well manured, but is so infested with weeds that the crops which are produced do not correspond with its fertility, and if a dead fallow is likewise bestowed upon it. In this case, the expenses attendant on such amelioration will soon be repaid by the benefits resulting from it. Lime should not, however, be used when any other equally efficacious manure can be procured at a cheaper rate, as calcareous marl, soap lyes, or the ashes of burned peat. Every person can easily calculate for himself what will be the expenses attendant on ameliorating a certain portion of land with lime.

Lime can always be procured at the cheapest rate in those places which are in the vicinity of limestone quarries. It is also less expensive where that marlly variety of lime is found, which is moulded into form, in order to be calcined. One condition essential to this cheapness is, that all the combustible materials necessary for the preparation of it, as wood, coals, or turf, shall be plentiful in the neighbourhood of the places where the limestone is found, in order that it may be calcined on the spot without having to be carried to any distance for that operation to be performed. With respect to the carriage of limestone to any great distance, it must be recollected that when in this state it weighs nearly twice as much as it does after having been submitted to the action of fire, and that thus more labour may easily be lost by the conveyance of this additional weight than would be gained by calcining it at prime cost. Although pure lime is a much more efficient manure than that which is found intermingled with other substances, yet the latter may be used, provided that it does not contain above fifteen parts in a hundred of clay; it will still be very proper for calcination, and the proportion of sand which it may contain without detriment to its ameliorating qualities is even greater. Limestone frequently contains the oxides of metals, which give it a disagreeable colour, and prevent it from being used as mortar; this lime is also fit for the improvement of land. The use of lime which contains magnesia is objected to by Tennant and several other English agricultural writers who follow in his steps; they all pretend to remark that magnesia deprived of its carbonic acid is productive of very injurious effects on vegetation.

Opinions are not less divided with regard to the effect produced by lime on meadow land. I do not know of any experiments bearing upon this point which have been made with sufficient precision and attention to all the necessary modifications; but, so far as I am enabled to judge from the results attending this operation in different places which have come to my knowledge, I should think it is one in which we must proceed with all possible circumspection, and which is very likely to be attended with danger if the quantity of quicklime applied be in any degree liberal. I have been assured that, when spread over dry meadow land in small quantities, this substance is productive of very beneficial effects; but that it is wholly inefficacious on damp, moist meadows. It has frequently been remarked that quicklime promotes the vegetation of clover and of vetches.

Water which holds a great deal of lime in solution is productive of excellent effects when employed in watering meadow land, either by inundation or irrigation; in the course of this operation, carbonate of lime, in the form of a fine powder, is precipitated over the land.

Lime which has not been calcined is certainly productive of some effect; but, on the one hand, its action is not so evident or energetic as that of calcined lime, and consequently a greater quantity is requisite to produce a similar effect; and, on the other hand, it is difficult to pulverize it sufficiently: it is, therefore, only occasionally used in this state when divided into very small pieces.

The dust collected from roads constructed of limestone and calcareous gravel, is productive of very great advantage when conveyed to the neighbouring fields; indeed, there is little or no doubt that this dust contains various ameliorating substances. Very beneficial effects have likewise been known to result from the use of the dust procured from the workshops of marble and stonecutters.

Even old mortar appears to become decomposed in time, especially if brought into contact with substances in a state of putrefaction. This matter is productive of a very striking effect on meadow land, but one which does not show itself until after a lapse of years.

Marl, as we have already observed, is composed of clay and carbonate of lime, intimately blended together in various proportions. The nature of these constituent parts give to it a double action when used as manure. It acts *physically* by means of the clay, and augments the consistence of loose and friable soils in a durable manner. Secondly, it acts *chemically*, by means of the lime, which renders soluble the humus and the undecomposed matter contained in the soil, and capable of being taken up by the roots of plants; but this latter action gradually diminishes, and soon entirely ceases. It is necessary to distinguish carefully between these two kinds of action. Marl is productive chiefly of the one or of the other, according as clay or lime forms the predominating ingredient in its composition. If we would have this substance to be productive of the first effect, and that to a very considerable extent, it will doubtless be necessary to bestow a much greater proportion of marl on the soil than would be requisite to produce the latter effect; and, in fact, its physical action can only be produced on light, loose soils; for land which is already too tenacious and clayey in its nature, would only be injured by an addition of marl, at least, as soon as the effects of the lime which it contained had subsided.

The intimate combination of the two component parts of marl renders it more efficacious than clay or carbonate of lime, or even than an artificial mixture of these two substances; because it readily falls to pieces of its own accord, becomes completely pulverized, and thus unites thoroughly with the layer of vegetable earth.

The utility of marl has been known and acknowledged from the remotest ages of antiquity; and this substance has been used wherever the agriculturists were of an enterprising disposition. Nothing but the general ignorance which has prevailed with regard to the actual nature and qualities of marl, has prevented it from being more valued and used than it has hitherto been. The idea formed of this substance is usually associated with that of a fossil of a certain nature and appearance; and hence it happens that as marl exists under an infinite variety of forms and colours, it is frequently not recognised by those who have seen but one species. Frederick the Great, whose ideas in reference to agriculture were definite and enlightened, but who was discouraged by the want of success which attended those ordonnances which he promulgated on this subject, and which arose from their not being generally understood, sent, in 1750, and during several subsequent years, for a number of labourers accustomed to the digging of marl, and commissioned them to travel over the marches and borders, and seek for this substance; but he received accounts from all of them, that, notwithstanding the most careful researches, they had been unable to discover any. There is, however, an abundance of marl in that country, and of exactly the kind which is best adapted to the nature of the soil. Those persons who were employed to seek for it came from mountainous countries, and, in all probability, were only acquainted with stony marl, a species which is seldom found anywhere but in hilly districts. Clay marl, which is the kind usually found in layers beneath the surface of plains, was scarcely known; and in those places where it had accidentally been used, as was the case in the principality of Pretz, in Holstein. The beneficial effects resulting from it were ascribed to the clay; and, therefore, clay which was not of a marly nature was frequently used for the purpose of improving land there; but, as may be expected, without any of the anticipated benefits being derived from the application of it. It is to chemistry that we are indebted for the solution of these apparently contradictory facts.

Another circumstance which has prevented marl from being more generally used, is the abuses which have crept into the practice of marling. In places where its ameliorating effects are known and appreciated, many agriculturists have calculated that marl would prove a cheaper manure than stable dung; and have, consequently, determined to do without the latter altogether; and, therefore, have diminished their stock of cattle, and sold their hay and straw. It may easily be imagined that as soon as the chemical effects of the marl ceased to operate, as must be the case when the land no longer contained undecomposed or insoluble substances, the soil became sterile, and a second marling was incapable of producing any beneficial effects, there being no humus for it to act upon. This circumstance gave rise to the old proverb, that marl enriches the parents, but impoverishes the children. Where a judicious system of cultivation is maintained, this proverb is, however, entirely without foundation; for marl progressively augments the fertility of the soil, by increasing those products which tend to add to the quantity of the dung.

At p. 321, we have spoken of the nature of marl, of its characteristics, its varieties, and the situations in which it is found. We have now, therefore, only to speak of its use and preparation.

As the carriage of this substance is the principal and most expensive part of the operation of marling, it is necessary, in the first place, to endeavour to procure it from some spot as near as possible to the land on which it is to be used; even supposing that at this spot the marl should be situated at a very great depth below the surface, and, consequently, very difficult of extraction, that inconvenience will always be compensated by the proximity. This consideration becomes still more important when it has reference to clay marl, which is to be applied to a light soil, in order to increase its consistency. Fortunately, in most countries where this variety exists, it is generally found extended in a continuous layer a little below the surface of the soil; while calcareous and stony marl is amassed in isolated places, and, consequently, has frequently to be brought from a very great distance: but this latter is seldom used in such large quantities, and, therefore, this circumstance is not of so much moment.

When there is not any material difference in the distance, those places should be chosen for the raising of marl, in which this substance is situated, at the least depth below the surface, and where the pit that is to be sunk will run least risk of being inundated with water. In flat countries, marl will always be found nearest to the surface at the summits of hills, and especially of those the surface of which is covered with a brown clay.

Previous to opening a marl pit, the land should be sounded in various directions, or little holes dug in different places, in order to ascertain whether the marl is of the proper kind, and whether or not it exists in sufficiently thick layers. It is seldom, however, that a continuous bed of marl, uninterrupted by veins or beds of sand, is to be found. But we must not suffer ourselves to be discouraged by this slight inconvenience; for it is very easy, when extracting the marl, to throw aside all that is useless, or to use it in filling up those places where we have dug most deeply.

It is as well to analyze the marl previously to applying it to the land; for it is seldom found to be of a homogeneous nature. Its constituent parts usually vary in different places. The best way of proceeding is, therefore, to analyze that taken from several different places, and then estimate the average composition of the whole from the results of these several examinations; because, in carting and conveying it to the land, it will always become pretty well mixed and amalgamated together. The more sandy the soil which is to receive an amelioration of this nature, the more useful will clay marl be which contains a small portion of lime. This clay may be advantageously applied to such soils, even when it does not contain more than from twelve to fifteen parts in a hundred of lime; but when this is the case, a much larger quantity of marl must be bestowed on the land, if we would have the effects of the lime become evident. The only kind of marl which is not beneficial to these soils is that which contains a great deal of sand. On the other hand, clay marl does not suit argillaceous soils: we must always endeavour to obtain marl for this kind of land which contains, at least, forty parts in a hundred of lime, if not more. Silicious marl, which often contains a great deal of lime, so far from being injurious to argillaceous land, is often peculiarly beneficial. The stony marl, which is found in mountainous districts, is particularly adapted for clayey soils, because it contains a small portion of alumina and a great deal of lime and fine silex.

When we are convinced that the marl is adapted to the purpose for which it is intended, and that it exists in a sufficient quantity, the first step to be taken is to remove the earth by which it is covered. The portions of earth thus taken away may frequently be used to fill up excavations which have previously been made in the vicinity; but where this cannot be done, they must be so disposed that they shall not fall back into the pit, and yet shall be sufficiently near to admit of their being thrown into those places whence all the marl has been extracted, and which we wish to fill up. As all the operations connected with the raising of marl ought to be executed as far as possible by the task or job, this one should be included, and calculated by fathoms or cubic yards. If the earth has only to be conveyed a short distance, wheel-barrows may be used for the purpose. Sometimes it is merely necessary to throw it up on the edge of the excavation by shovels.

It is sometimes necessary to uncover the whole surface of the marl pit, while in other cases it is better to open only a portion of it. This is especially the case when it is not intended to dig deeply, and when the places whence the marl has been extracted are to be filled up by the earth which covers those portions yet untouched. The operation may be carried on in this way from the foot of a hill containing marl, to its very summit. But when it is the intention of the agriculturist to excavate to a greater depth, which he will often be the more disposed to do, from the circumstance of his finding the marl more homogeneous and calcareous the deeper he penetrates, it will then be necessary to uncover the whole of the pit, in order to be able to work with greater facility, and to avoid the danger of the earth falling in. An extent of eight perches in length and six in width forms a very fair-sized marl pit; but there have been cases in which this extent has been doubled.

Every marl pit must be provided with an entrance and an exit, in order that the waggons may pass through it, and not be obliged to turn; and both these roads must be gently inclined, in order that the descent and ascent at the entrance and transit may be effected with as little difficulty and labour as possible.

In extracting the marl and conveying it to the land to which it is to be applied, as equal a proportion as possible should be established between the number of labourers employed in digging and loading the waggons, and the teams for transporting it, so that neither shall have to lose time by waiting for the other. This proportion will, of course, be varied by the distance to which the marl has to be conveyed, the depth from which it has to be extracted, its tenacity, the state of the temperature, and the quantity of water which is collected in the pit. Matters must be so arranged that there shall always be a cart, waggon, or wheel-barrow in the manure pit ready to be loaded, but which shall not have to wait. The labourers employed in digging and loading should not be allowed more time than is absolutely requisite to enable them to dig out sufficient marl to load the waggon. If the distance is short, and the operation progresses rapidly, one set of labourers must be employed in digging while the others are loading.

When the distance is considerable, and the teams cannot return so quickly as they would if they had a shorter space to traverse, the number of labourers must be diminished, or more teams must be employed. This matter may easily be regulated by reference to locality, &c. Those persons who find that they have fewer labourers than they have teams, should cause the marl to be conveyed to the most distant fields; while those who find that they can command a greater number of labourers than of teams, can have the marl carried to those portions of land in the immediate vicinity of the marl pit.

When the operation of marling is performed by persons who undertake it by the task or job, they sometimes furnish the waggons and teams; while, at other times, their employer finds them. In the latter case, when the greatest distance which the marl has to be conveyed does not exceed from eight hundred and forty to nine hundred and sixty Rhenish feet, the sum paid for a waggon containing eighteen cubic feet will be ninepence. If the employer finds his own drivers as well as his own teams, he will not have to pay more than six or eight pence. I pay about a shilling here for such a load. It is, of course, understood that this price supposes that there is no particular difficulty attending the extraction of the marl, and that this substance has not to be dug from any great depth. This is the usual way in which these matters are arranged when the plough horses are used in conveying marl, and when the agriculturist does not choose to entrust his cattle to strange labourers, but rather that they shall be driven by their own carters and drivers.

Local circumstances can alone enable us to decide on the expediency of keeping or hiring horses expressly for the performance of this operation, or making use of those teams which are kept for the performance of the various operations of tillage when not otherwise employed. If it is intended to conduct the operation on an extensive scale, the former course is unavoidable; for, if the latter were adopted, the marling would only proceed when the labourers and teams were not otherwise employed. Whenever teams are kept expressly for the purpose of conveying marl, it will also be necessary to keep labourers solely for the performance of that work.

The kind of vehicle used is generally adapted to the cattle which are employed. When horses are kept expressly for this purpose, tumbrels drawn by one horse will be found to answer best, and in time the animals become so accustomed to their duty that one driver will suffice for two or three of these carts; but where the ordinary teams are used, waggons drawn by two horses are preferable. I am no advocate for the use of teams of four horses, unless the distance is very considerable or the roads are heavy. Where such is not the case, two horses will draw almost as much as four. I could never make a team of four horses draw more than a load of twenty-five cubic feet at most, while two horses will usually draw a load of eighteen or nineteen feet. A Rhenish cubic foot of marl in its ordinary state of humidity weighs from a hundred to a hundred and three pounds, Berlin weight.

It is seldom that any marl, and especially clay marl, is homogeneous in its nature throughout the whole extent of the pit. In some layers or particular spots it will be found to contain an amazing quantity of lime, while in others it contains but very little. Those who are not sufficiently accustomed to it, and unable to distinguish these variations in its constituent parts by examination or touch, will do well to have recourse to a superficial analysis. In general, the deeper we penetrate the more homogeneous does the marl become; veins or beds of sand are often found intersecting it. This sand is sometimes of a calcareous nature, and is then exceedingly beneficial to clayey soils, or may be advantageously mixed with mould and peat. But even if no use can be made of the sand or clay thus found, and which seldom contains much if any lime, it must still be separated from the marl and got rid of; and in this case the best course of proceeding is to throw it into those excavations whence no more marl is to be extracted.

The thickness and nature of the layer of marl can alone enable us to decide on the expediency of excavating to any great depth. In general, the further we penetrate into the layer the more calcareous is it found to be; but then the expenses attending the operation, the labour, and the danger, will be considerably increased, and even doubled, unless very great precautions are taken. Marl extracted from a great depth will have in the first place to be thrown on a kind of scaffold before it can be carried to load the waggons, hence both the labour and expense will be doubled. Unremitting attention must likewise be bestowed on the whole progress of the excavation, to sec that the walls do not bulge in the slightest degree, or the workmen deviate from the perpendicular; for, should either of the sides of the pit fall in, very serious mischief would be inevitably occasioned.

When the pit is excavated to any great depth, the workmen frequently have to contend with springs of water, which rise from the surface of the soil or filter through the veins of sand; and it not unfrequently happens that this influx of water is so great that it becomes necessary to abandon the pit altogether. Hence, we seldom find marl-pits excavated to more than from six to twelve feet below the surface. Some agriculturists have, however, extracted very good marl from twice that depth.

The quantity or proportion of marl that should be applied to a field varies greatly, being influenced by the nature of the substance itself, of the soil to which it is applied, and the end which is to be attained by its application. The more calcareous marl is, the greater will be the effect produced by it, and, consequently, the smaller the proportion which it will be necessary to apply. A marling in which from twenty to twenty-five loads, each containing eighteen cubic feet, is allowed per acre, is considered to be sufficiently abundant for almost any purpose: this species of marl ought to contain at least sixty parts in a hundred of lime; it is used in the amelioration of clayey or argillaceous land.

The more that clay predominates in marl, the greater must be the quantity of that substance applied to any portion of land, especially if that land be of a sandy nature; because, independently of the chemical amelioration which it receives, the soil will thus likewise derive a durable physical improvement. The marl is spread over the whole surface of the field in a layer of an inch thick, which takes about one hundred and twenty such waggon loads as we have been speaking of per acre. In most countries, when the practice of marling is first adopted, quite as much marl as has just been stated, if not more, is used; and there is no doubt that a durable improvement of the nature of the soil is thus produced. But I have always observed that in proportion as the agriculturists become more acquainted with the details and results of the this operation, and practise it on a more extensive scale, they become more economical, and reduce the quantity of marl above-mentioned to sixty, and sometimes even to forty loads per acre; and they find that this marling is productive of the requisite effect: the only difference is that the effect is not so durable, and does not last more than from ten to twelve years. But then much greater advantages are derived from a repetition of the operation, after a lapse of twelve or sixteen years, than would have been obtained if a very abundant manuring had been bestowed in the first place. Most persons have, therefore, been led to prefer the application of marl in small quantities, frequently renewed. Sixty loads of marl, which contains about twenty-five parts in a hundred of lime, is the usual proportion; and the layer which this amelioration will add to the soil is about an inch thick. If the marl contains much less lime, a considerably larger quantity must be employed if we would have it to be productive of equally satisfactory results; but marl containing fewer than twenty-five parts in a hundred of lime is only calculated for sandy soils.

The differences in the quantity of marl used, and in the consistence and nature of the soil, will serve to explain all those apparently contradictory results which have attended experiments on repeated marlings. A second or a third marling has sometimes not only been unattended with any good results, but has even been productive of baneful consequences; while, at another time, a second marling has been attended with more beneficial results than the first. In the former case, the soil already contained an abundance of all that the marl could bestow; but it had not been properly manured, and common marl is incapable of restoring humus to an exhausted soil. If the marl applied was clay marl, it is possible that the evil arose from the soil being of an argillaceous nature, and thus becoming saturated with clay, and actually deteriorated. In the latter case, the land had been well manured, the physical properties of the marl were adapted to the nature of the soil, and thus the consistence of the latter was sensibly ameliorated. In districts where the land is regularly marled at certain intervals, and a sufficient quantity of manure is also applied to it, it is generally considered that, when some particular weed or weeds choke the crops, infest the soil, and shoot up luxuriantly all over it, this land requires marl rather than dung. Whenever this is the case, the operation of marling, which must of necessity be accompanied by a dead fallow, not only destroys the weeds, but fertilizes the soil much more than manure would do; for the vigorous vegetation of the weeds tends to prove that the soil contains an abundant supply of those juices which are necessary to the nutrition of plants, but that these juices are more adapted to weeds than they are to cereals. The chemical action of the marl, in all probability, totally changes the nature of the humus.

But, in all those countries where the land is frequently and regularly amended with marl, only a very moderate quantity of that substance is applied. It is seldom that more than from twenty-five to thirty loads of argillaceous marl are bestowed on an acre of sandy land; or that more than ten loads of calcareous marl are applied to an acre of argillaceous land.

There are various opinions with regard to the duration of the effects produced by marling, and, in point of fact, this duration must of necessity be influenced and varied by circumstances. A considerable addition of argillaceous marl will afford a durable amendment of the physical properties of a light sandy soil, and will render it capable of bearing more luxuriant and abundant crops than heretofore, provided that it is properly manured. The chemical effect of marl will be perceptible during a period of from ten to twenty years, according to the quantity of that substance which has been applied to the land. The effects of calcareous marl on a clayey soil can seldom be said to endure more than ten or twelve years. It is according to a calculation founded on this proportion, that in many districts farmers are repaid the expenses incurred by those marlings which they have bestowed on the land during the time it has been in their possession, but of which the expiration of their lease has prevented their reaping all the benefits. Thus, for example, if a farmer has enjoyed the benefits arising from this operation only for five years, he is repaid $\frac{7}{12}$ of the expenses; but if he has enjoyed them for nine years, he only receives $\frac{3}{12}$.

In general, the improvement resulting from marling goes on increasing to the third year, provided that during this period the land is properly manured; and after that time it progressively declines. But this result depends in a great measure on the disposition of the marl to become thoroughly divided and to fall to powder, since it does not produce its beneficial effects until it becomes completely blended and incorporated with the soil: this is the reason that it is so imperatively necessary to bestow all the proper operations of tillage on land to which marl has been applied.

When horses are kept expressly for the performance of this operation, as is the case in all those places where marling is practised to any great extent, the work may be carried on without interruption during the whole year, so long as it is not impeded by alterations of temperature, or by frosts which have penetrated deeply into the ground. But where the marl has to be conveyed by the ordinary farm teams, and sometimes even by oxen, the operation can only be performed during the latter end of autumn, the winter season, and the intervening period between the spring seed time and the harvest. Marl conveyed to land during winter, or at the latter end of autumn, acts very promptly on account of its being completely divided and pulverized by the cold and frosts. When the ground has not become too much hardened by frost previous to being covered with snow, it is worth while to remove this latter substance from those places where we wish to dig, and to break the frozen parts, and convey the marl to the land over which it is to be spread on sledges. Marl which is not carried to the land until winter is nearly or quite gone, seldom becomes sufficiently pulverized to be minutely and intimately blended with the soil, even though it shall have received repeated ploughings, and, consequently, is productive of little or no effect on the first crop of autumnal corn. The English system of marling is seldom used here; they insist that, previously to its being buried, the marl shall be spread over the soil, and suffered to remain there, exposed to the burning sun of two summers, and the cold and frost of one winter. If, as is generally the case, the marl is applied to the fallow after the first ploughing has taken place, it will be necessary, in order to follow out this practice, to bestow two successive dead fallows upon the land. But English agriculturists likewise marl land which is at rest, or laid down for the production of artificial grasses; which then shoot up luxuriantly, and yield an abundant crop of pasturage.

Marl which has been put on the land before the commencement of winter, and suffered to remain there until the middle of summer, will generally be pulverized sufficiently to be thoroughly incorporated in the soil by repeated ploughings, harrowings, and rollings. But when this substance has not been conveyed to the fields until spring, it seldom becomes sufficiently pulverized and reduced, and remains in the soil in lumps and clods after it has been turned in. That which has been spread over the land before the commencement of the winter, produces an immediate effect; while the effect of that which is not spread until the spring, is very tardy, and, in fact, is scarcely perceptible during the first year.

Some agriculturists who wish to obtain immediate benefit from the marl which they apply to their land, sow crops of spring corn upon it, as barley, oats, or buckwheat; but, in general, with little success. A carefully tilled, complete, dead fallow is indispensably necessary to ensure the good effects of marl, and to render them speedily evident.

It is almost superfluous to state that the marl ought to be spread over the land as carefully and equally as possible. After this has been done, the land should be well harrowed in dry weather; and if any lumps of marl still remain undivided, the roll should be passed over it; and, subsequently, when the marl has been moistened with rain, and again become dry, the harrow should once more be used. The first ploughing may then be bestowed, which must be as light as possible. Afterwards, three other ploughings should be given, and each succeeded by a harrowing, and then the intimate blending of the marl with the soil may be left to nature. If the marl still continues lumpy, this combination cannot take place, nor will that substance become incorporated with the soil until after the lapse of a considerable period. Those portions of marl which are not mixed with the soil in the form of a fine powder, are not only wholly inefficacious, but positively injurious to vegetation.

The expenses attendant on marling must necessarily vary considerably under different circumstances and in different localities. The labour attending the extraction of this substance, and the loading of the vehicles in which it is to be conveyed, will depend, in a great measure, upon the depth from which it has to be raised. The tenacity of the marl also, and the quantity of water with which the labourers have to contend in the pit, cannot fail to have considerable influence on the expense of the operation. When the marl can be carted and carried away as soon as it is detached, the usual price of a load of eighteen cubic feet is from six to eight *deniers.** In Holstein, one shilling and sixpence is usually paid for the same quantity; and, for this sum, the labourers are expected te get the marl, fill the carts, and spread it over the land, provided the distance of the fields from the pit admits twenty-five loads per day being carried, and they are found in teams and vehicles. I pay one shilling for the cartage of such a load, and find teams, and mattocks, and drivers: at this rate, the labourers are well paid.

The expenses of carriage depend entirely upon the distance. It not unfrequently happens that calcareous marl is conveyed to argillaceous land which is, at least, a mile distant; and, where this is the case, one team cannot convey more than two loads per day, and sometimes not more than one. The operation of marling will then prove an expensive one, and will often cost even more than an amelioration of lime. Clay marl can only be used in the immediate vicinity of the place where it has been extracted: attempts are therefore made to procure it from each field, or from the nearest possible spot. When the distance is once known, it is easy to calculate the number of loads which one team can convey in the course of a day.

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* 12 Deniers make 1 groschen, and 24 groschen 1 rix-dollar, which, in English coin, is worth from 4s. to 4s. 3d., and in some parts of Germany even as much as 4s. 6d. According to this calculation, therefore, the expenses attendant on the marling of an acre of land will be from £1 or £1 1s. to £1 2s. 6d.

The following will be found to be the usual amount of the expenses attendant on the marling of an acre of land.

| | Rix-dol. | Gros. |
|---|---|---|
| To getting and filling 60 loads of marl, at 8 deniers per load | 1 | 6 |
| Two horses, which will in general be able to convey the quantity requisite for an acre of land in 3 days, at 8 gros. each per day | 2 | 0 |
| Spreading the marl over an acre of ground | 0 | 8 |
| Cost of opening the marl-pit, and other incidental expenses.. | 0 | 6 |
| Wages of the driver, at 6 gros. per day | 0 | 18 |
| | 5 | 0 |

It must be borne in mind, that in this estimate all attendant circumstances are considered to be favourable. In proportion as the difficulties of the operation increase, so will the expenses be augmented. During the short days of winter, not more than fifteen loads per day can be carried; while, in the summer, when the days are long, as many as twenty-five can be conveyed with ease. In the former season, therefore, the daily work done by the teams must be estimated at a lower rate, in order that the valuation may be increased in the summer.

I knew a case in which, in order that the marling of a field situated at a considerable distance from the farm buildings might be executed as quickly and with as little delay as possible, vetches were sown on those portions of land which had received this amelioration; and the teams employed in conveying the marl were thus fed: they were left there night and day, and tethered with cord to prevent them from treading down the plants beyond the space immediately assigned them.

The use of marl is always attended by evident and beneficial effects, especially when argillaceous marl is applied to a sandy soil; and advantageous results have been obtained even when after several years of rest the land has appeared so exhausted and sterile as scarcely to be worth the trouble of sowing it. Nevertheless, this effect is only relative, and by no means absolute. The produce is increased from two and a-half to five bushels per acre for several crops, and especially at the third crop; but it subsequently declines progressively, unless the land is laid down to rest for a considerable period, or manured with stable dung. But the effect of marl is far more evident and beneficial on land which still contains both succulency and humus, which is manured from time to time, and laid down to grass before it becomes exhausted: in this case ten bushels of produce per acre is frequently obtained from a field which, had it not been manured, would not have yielded more than four bushels.

The effects resulting from this amelioration will be rendered greater and more durable if an addition of stable-manure, ever so small in quantity, be combined with it. When the land is not in very good condition, it is as well to bestow four loads of dung on it, either when it is marled or in the following year at the latest. Should the land, however, be tolerably fertile, it is to be feared that such a course of proceeding would have the effect of laying the corn; two or three crops of cereals may, therefore, be raised after the marling has taken place, and then an amendment of stable-manure be bestowed on the land. But so soon as this latter appears to be necessary it should be given, otherwise the soil will become more exhausted than it would have been had it not been marled, and it will be a very difficult matter to bring it into good condition again.

It is likewise advantageous to make use of marl, together with peat or mould, in the form of a compost: this mixture is productive of prompt and sensible effects even on an exhausted soil.

In England the attempt has been made, and with great success, to bury a crop of green buck-wheat as manure. Spergula, or spurrey, is equally well adapted for this purpose.

Of all this class of ameliorations, marling is the one which can in general be effected with least difficulty; it is one of the most durable, and, if we except a very few others, is that which is attended with the greatest advantages.

There is also another earth which is productive of astonishing effects when employed as manure, which contains a considerable proportion of lime, and is besides very rich in humus. It is found in those low situations which have in all probability once formed the beds of rivers, or at all events have been covered with water. This earth is of a bluish colour, and resembles a very friable poor clay; it is soft to the touch, and is frequently intermingled with small shells. It is seldom found immediately under the vegetable soil; a sterile layer of clay usually intervenes between the two, which must be broken through and removed before we can reach this substance. I have analyzed a portion of this kind of earth which was obtained from the marshes of Oldenburgh, and the following were found to be the proportions of its constituent parts:—

| | |
|---|---|
| Fine sand, one-half of which could be separated by washing and the other by boiling | 36 |
| Carbonate of lime | 14 |
| Humus | 5 |
| Fat clay | 44 |
| Gypsum | 1 |
| Total | 100 |

The humus was evidently of an animal nature, and when burned emitted a fetid odour. I have no doubt that this fertilizing and ameliorating earth might be found in many places where its existence is yet unknown; it is composed of the residue of plants, fishes, and testaceous or shelly matters, in a greater or less degree of attenuation, deposited among fine sand, and which have subsequently been covered by depositions of those matters which have been washed down from the elevated spots by rain or by currents of water. It is well worth while to take the trouble of digging and searching for this substance in all those valleys which appear to have been once covered with water.

The following is the manner in which this earth is usually extracted:—

In the first place, a pit or excavation, of about six feet in width and twelve in length, is opened; the layer of vegetable soil is thrown up on one side, and that of virgin clay, which is usually about four or five feet in thickness, on the other. This ameliorating earth which is found underneath is then extracted, and the excavations in search of it are carried to as great a depth as they can be without danger; the pit or opening is then extended, and those places whence the earth has been extracted are filled by throwing into them the clay and vegetable soil before mentioned; and so the operation is carried on until a sufficient quantity of this earth has been obtained.

This earth is, in itself, perfectly sterile, at least when first extracted; but after having been mixed with the soil and carefully tilled, it renders the latter exceedingly fertile. Land which has been thus ameliorated is distinguished for a considerable period by its wonderful fertility.

A knowledge of the advantages resulting from the use of gypsum (sulphate of lime) is by no means a discovery of recent date. We find many traces in the annals of antiquity of its having been known and used in isolated countries and places, but its use as a manure was but very partially introduced until about the middle of the eighteenth century, when Herr Mayer, a clergyman of Kupferzell, in the principality of Hohlenlohe, noticed it in a correspondence with Count Von Schulenberg, of

Hehlen, in the electorate of Hanover, as having been long used in the neighbourhood of Gottingen as a manure. The reputation of gypsum was widely diffused by the writings of Mayer. Tscheffeli, the zealous Swiss agriculturist, soon afterwards tried experiments with it, and the success with which they were attended introduced the use of it into Switzerland. An account of the experiments made by Tscheffeli, as well as those of other celebrated agriculturists, to ascertain the properties and use of gypsum, will be found recorded in "Les Memoires de la Societé Econimique de Berne." Shoubart and Kleefeld were the first German agriculturists who made known the beneficial effects of gypsum when used as a top-dressing for clover. But several persons exclaimed against this practice; and after making, or pretending to make, various imperfect experiments, to say the least of them, declared this substance to be wholly inefficacious if not injurious. This question was discussed for a long time, without arriving at any satisfactory conclusions.

Among the opponents of gypsum were all the proprietors of salt works, who feared that if it came into general use, they should no longer find a ready sale for the residue of their manufacture, which had previously been used in all the neighbouring districts. On the other hand, the use of gypsum as a manure soon spread among the agriculturists of France, especially in the vicinity of Paris, whence it extended to America. From the very first moment that it was made known in this latter country, large cargoes of it were imported from Montmatre.

The use of this substance was more rapidly extended in the provinces of North America than in any other part of the world; and nowhere has it found fewer partisans than among the agriculturists of England. In my work on English agriculture, I have given as a reason for this neglect the quantity of calcareous particles which the soil of most of the counties of England contains, either naturally or artificially; but I was wrong in so doing, for the effect of gypsum is equally as sensible on land which has been well supplied with calcareous particles, as it is in those counties where there is a great deal of gypseous rock, and where, to all appearance, the soil contains a considerable portion of gypsum. Perhaps the prejudice which exists in England against every thing and every discovery that is introduced by France or even by Germany, may have in a great measure tended to render the agriculturists of that country blind to its utility. They seem inclined to tolerate and adopt only the discoveries and practices of the Americans.

It cannot be denied that many of the experiments made with the view of verifying the effects of gypsum as a manure, have been attended by the most contradictory results; and it is an undoubted fact that its effects are modified by various circumstances that have not as yet been sufficiently inquired into. The effects resulting from the use of this substance are much greater on dry soils than they are on those which are moist and damp; and more sensible in dry than in rainy or wet weather. A moist state of temperature retards the effects of gypsum, and sometimes appears to suppress them altogether, especially if the gypsum has been calcined. This substance is not productive of any effect on an exhausted soil which contains but little humus. Its influence on the vegetation of some plants is very trifling, while on others it exercises a marked power. Those plants on which gypsum appears to produce the most sensible effects, belong to the papilionaceous and cruciform orders. There is no doubt that gypsum acts upon the plants themselves, and, consequently, is more efficacious when its dust attaches itself to their leaves and remains there for a considerable time. I received a very striking proof of this effect in a case where the wind had carried the dust of powdered gypsum over one side of a hedge of whitethorn, which, in about eight days, began to put forth rich and luxuriant foliage, while the other side, which had not come in contact with this fertilizing dust, remained very much behind. But gypsum does not act solely in this way, as I was once inclined to think that it did; but I have since been convinced, by recent experiments made on the subject, that it likewise acts on the soil. In the autumn of 1808, we spread this substance over an acre of land, which was carefully marked out and sown with rye. In the spring of 1809, white clover, intended to form a pasturage, was sown on this field, which was considerably impoverished; this clover failed almost everywhere, excepting on the acre ameliorated with gypsum, where it was so thick and luxuriant that this spot was eminently distinguished from all the surrounding land.

We have already stated the manner in which gypsum acts upon the soil. In all probability it enters into a reciprocal but very slow action with the humus. This latter substance decomposes the acid portion of the gypsum, and thus produces carbonic acid, or some yet more compound substance. It is not as yet known what is the nature of the matter thus formed, and in all probability never will be, on account of the rapidity with which it decomposes. It is probable that the sulphur, thus deprived of oxygen, blends with the lime and with a portion of the hydrogenated carbon, and that this combination produces the fetid odour which is disengaged when gypsum is combined with substances in a state of putrefaction. From all appearances, we are led to believe that this carbonic acid and its new combinations are peculiarly adapted for the nourishment of certain plants. Hence it happens, that the effect of gypsum is proportionate to the quantity of humus or other substances in a state of putrefaction which it meets with in the soil over which it is spread.

Gypsum is chiefly used in the cultivation of clover, or other plants of a similar nature, and sometimes also for vegetables. As it is productive of a sensible effect on those of the cabbage kind, I am inclined to believe that it would also be beneficial to rape; but I do not think there are yet on record any well-attested experiments calculated to demonstrate the truth or fallacy of this supposition.

Gypsum is used both in a calcined and an uncalcined state, without the effects produced by it appearing to be very different; unless, indeed, a heavy rain falls immediately after this substance has been spread in the former state, when the powder will be agglomerated, converted into hard stony lumps, and rendered wholly inert. The most important point to be attended to, is to see that the gypsum is powdered as fine as possible; it should be literally reduced to dust if we would have it productive of the most beneficial effects; this is a very difficult matter when the gypsum has not been calcined, but gypsum which has been submitted to the action of fire may easily be reduced to powder.

In some places this pulverization is effected at a very small expense by means of water mills; but in situations where no such mills exist, recourse is had to various other contrivances. The gypsum is then placed in mortars or troughs, and pounded with pestles or other instruments used for the purpose of bruising millet or making oil of rape, or broken in pieces by means of a grindstone. When it is thus pounded, it is passed through a sieve, and those parts which do not appear to be sufficiently pulverized, are pounded or ground afresh. After having been thus prepared, it must be kept in a dry place, in order that it may not absorb that humidity which would tend to restore to it some portion of its former adhesiveness.

A calm day should be chosen for the purpose of strewing gypsum, when there is little wind, and when the dews have been heavy; the time chosen for the performance of this operation should be late in the evening, or early in the morning, especially when it is used as a dressing for clover, because at these times the dew on the leaves of the plants will cause it to adhere to them. This kind of amelioration should never be applied in windy or in rainy weather. Gypsum seldom appears to be productive of more beneficial effects than when used as a top-dressing for clover, the vegetation for which is already sufficiently advanced to enable its leaves to cover the soil; this operation ought, therefore, generally to be performed about the beginning of May. Some persons have, however, derived advantage from strewing it over the young clover plants in autumn. It is not unfrequently used as a dressing after the first cutting has taken place, and with the view of accelerating and increasing the vegetation of the second; and where this has been the case, the second cutting has been found to yield far more than the first, and which it would not have done under other circumstances. The quantity of gypsum requisite for an acre of land varies from one to two bushels. When it is properly pulverized the former will be sufficient; but if such is not the case, a larger quantity must be applied.

All the experiments which I have yet been enabled to make, or of which I have had an opportunity of watching the progress or inquiring minutely into, tend to convince me that gypsum is productive of evident and beneficial effects, unless these are counteracted by heavy rains, variations of temperature, or some negligence or inaccuracy in the experiment. I do not, therefore, hesitate to recommend the use of this substance as a means of increasing the vegetation of clover, and rendering it both vigorous and luxuriant, wherever it is obtained sufficiently cheap to make the expenses attendant on an amelioration of a bushel and a-half per acre not exceed one rix-dollar and eight groschen, or five shillings and eight-pence in English money. If the land is in tolerable condition, although not excessively fertile, we may expect to obtain from six to eight quintals of clover from it, beyond what it would have yielded without the intervention of gypsum; it being of course understood that the plants were pretty thick, since gypsum cannot create them where they do not exist. If, however, there is one plant on each square foot of land, the effect of the gypsum will be such that at the time of flowering the clover will completely cover the soil. But, on the other hand, should the clover be very thick and the soil sufficiently rich and fertile to admit the plants shooting up luxuriantly without any extraneous aid, a dressing of gypsum would only produce an excess of vegetation, and tend to dispose the plants to rot; and where such is the case, it is as well to abstain from the use of this substance.

All the experiments that have hitherto been made seem to prove that gypsum has little or no direct effect on gramineous cereal plants when spread immediately over them; but it is the unanimous opinion of every one who has had the opportunity of observing this point, that the stubble of a clover crop which has been dressed with this substance produces much finer cereals, and especially wheat, when turned in as manure, than are ever obtained where the gypsum has not been used. This effect appears to have been produced by the tendency of the gypsum to augment the vigour and succulency of the roots and stems of the clover, and thus to increase those portions of its residue which this plant leaves both on and in the soil. It is a well-known fact, that the vigour and fineness of corn crops succeeding to clover is always proportionate to the vegetation of that plant. Thus, then, the use of gypsum is indirectly, if not directly, favourable to cereals; it is also productive of still greater advantages by the increase of fodder, and likewise of dung, which it procures.

This species of manure, which, from the smallness of the quantity of it that it is necessary to apply to the soil, may be procured from great distances without much inconvenience or expense, is then a very valuable one; but it must not be forgotten that no effect can ever be expected from its application to exhausted land.

Gypsum leads us to speak of other salts which may be employed for the purpose of ameliorating the soil. But, if we except the residue of salt works, these substances are seldom used for this purpose, on account of their being in general too expensive.

The experiments hitherto made with regard to the use of these salts have been for the most part limited and partial. Most of them, and especially those which relate to common salt (muriate of soda), have been attended with the following results:—When applied to the soil in too large a quantity, this substance has completely checked vegetation; but when the salt has been washed by heavy rains, and perhaps partially decomposed, it gives a degree of strength and vigour to the vegetation of the succeeding years. If a small quantity of it is spread over a very rich soil, the effect produced by it is very sensible but of short duration: on the other hand, if this small quantity is spread over an impoverished soil, no effect whatever is produced. This mode of ameliorating land is therefore seldom practised even in the neighbourhood of salt mines, where it can be procured at a very low price. But, on sea coasts, the effects produced by salt water on vegetation become strikingly evident: this is the reason that salt marshes are preferred to others for the pasturage of cattle. The grass which grows on such places is eaten with avidity by all kinds of cattle, whether as pasturage or in the form of dry fodder; and it is peculiarly wholesome and nourishing to them. But even on the sea coast the salt is speedily carried away from the soil by rain or other kinds of moisture: indeed, when land of this nature is analyzed, few vestiges of saline matters are to be found in it.

The experiments made with regard to the use of saltpetre (nitre, or nitrate of potassa), employed in very small quantities, have been attended with much more evident and sensible results than those arising from the use of common salt: but in ordinary undertakings, this substance is not available on account of its being so very expensive; nor should we have spoken of it at all had not this circumstance tended to demonstrate the fertility of those soils which spontaneously produce nitrate of lime. We must, however, pause to observe, that many soils are supposed to contain saltpetre which really do not possess a particle of it; that whitish substance which is observable on all soils containing a considerable quantity of mould, and which is so often mistaken for saltpetre, is neither more nor less than a *lichen (lichen humosus)* which such land produces, and which certainly is a proof of fertility. That portion of saltpetre which the soil produces spontaneously is speedily washed away by rain or moisture; hence this substance is rarely found when land is analyzed;

it is much more frequently found in the plants which have sprung from such land; but it does not appear to form an essential portion of them, but rather to have entered into their composition accidentally, and to exist there as a foreign body: this is the case, for example, in wild beetroot.

It is not worth while to enter into any dissertation on the subject of the neutral salts.

Latterly, the metallic salts, and especially green vitriol, or sulphate of iron, have been considered as well adapted for the improvement of land. There was a time when this substance was regarded as exceedingly prejudicial to vegetation, and land impregnated with it was justly considered to be sterile. It is only within the last few years that theory and experience have combined to teach us the value and utility of green vitriol. When the importance of oxygen in the promotion of the germination of seeds and the early development of plants was first perceived, it was deemed possible to enclose this matter in oxides, acids, and acid salts; but positive effects were only obtained from those oxides and acids which were easily susceptible of decomposition, and allowed their superabundant oxygen to disengage itself. After having made various experiments in order to elucidate this point, the influence of acids and of acid salts on the germination of plants still appears to me to be very doubtful.

In the experiments on the action of green vitriol, or sulphate of iron, dissolved in water and used as a manure, the results appear to vary exceedingly; some persons have not been able to discover that it produced the slightest effect; others have found it injurious: while a third class have declared that they have derived considerable benefit from the use of it. In most of those experiments which I have had an opportunity of investigating, the quantity of this solution that was used, and the extent of land watered with it, have been by no means accurately defined; it is nevertheless very important that both these points should be ascertained, and unless we are acquainted with them it is quite impossible to explain the causes of those contradictory results.

Experiments undertaken by accident, and which tend to determine the ameliorating powers which some vitriolized fossils possess, have given to this subject an importance, in a practical point of view, which it would not otherwise have possessed. In England a species of peat strongly impregnated with vitriol has been found; and in Germany, in the estates of Reibersdorf, belonging to the Count d'Einsiedel, a mine of highly vitriolized coal has been discovered, both of which substances form very active manures when used in small quantities.

From the results of experiments made with these substances, it appears evident that vitriol, when combined with coal, exercises a powerful influence on vegetation. Possibly the action of light and air effects the decomposition of the sulphuric acid, the oxygen of which combines with the carbon and forms carbonic acid, or some other substance equally favourable to vegetation. Nor is it altogether improbable that, by means of the hydrogen which is united with the coal, the sulphur and the coal itself enter into combination, and contribute to accelerate and strengthen vegetation. Pure green vitriol, or sulphate of iron, can combine in the same manner with the humus which it meets with in the soil, and is then productive of the most beneficial effects. Further light must be thrown on this subject by the medium of patient investigation and carefully conducted experiments, ere we can venture to determine whether this substance is really capable of ameliorating land, and in what proportions it should be employed.

The great and incontestibly good effects resulting from the use of coal and peat impregnated with vitriol, ought to induce all persons to have it in their power to dig in search of these substances, and to use them for the amelioration of land.

When vitriolized coal is used as a manure, it is first reduced to powder, and then spread over the land after the last ploughing or sowing, but not buried. The quantity of this substance applied to the land must be regulated with the greatest circumspection and care. When used too plentifully, it is injurious; and if it is suffered to remain on the soil in heaps only for a few days, every trace of vegetation disappears for several years from the spots where such heaps have stood. It ought, therefore, only to be unloaded on the roads, or on the edges of land where little or nothing is sown. When the soil is of an argillaceous or calcareous nature, from 30 to 36 bushels per acre may be applied to it; but not more than from 15 to 18 bushels must be bestowed on a calcareous soil.

The question of the ameliorating or non-ameliorating effects and properties of acids is a theoretical rather than a practical point, since it rarely happens that we are able to make use of these substances. Nevertheless, we will pause to make a few remarks on this subject.

In theory, the use of acids has been recommended for the purpose of ameliorating the soil on account of the oxygen they contain, which is in itself highly favourable to vegetation; the fact that their decomposition, when in the soil, is too independent of external causes, appears to have been wholly overlooked.

Those experiments which have been made with acids have been attended with very contradictory results: it is astonishing that the talented men by whom they were conducted should have omitted to inform us of the nature and composition of the soils to which they applied the acids. Various accessory circumstances tend, however, to induce the belief that it was only on calcareous soils that sulphuric acid was productive of beneficial effects, and this was the only acid with which experiments were made; its good effects are easily explained by the fact, that on land of this nature sulphuric acid produces gypsum, and causes the evaporation of the carbonic acid. Those soils to which it was prejudicial doubtless contained little or no lime.

Lastly, we must not omit to notice ashes as being one of the most active manures, as well as one which is very frequently used. When thoroughly burned, ashes are composed of earths and potash, to which are sometimes added metallic oxides and different salts. Lime is always the predominating earth which enters into their composition, even when the plants whence they are derived have not sprung from a calcareous soil.

It cannot be denied that potash contributes greatly towards the amelioration of land by its decomposing power; but, in general, ashes are not used until they have been lixiviated; notwithstanding which, they are still productive of considerable effect, although not so great as would have been derived from their use if they had not been submitted to that process. Ashes must contain some peculiar and hitherto undiscovered matter, which gives to them an action so much more efficacious than that of an equal quantity of the same earth which they contain, and taken in another state. It is possible that some portion of vegetable life remains in them which we are unable to appreciate or discover. A circumstance which seems to tend greatly to the support of my opinion is, that it has been everywhere observed that ashes resulting from the combustion of a slow fire, and which have been formed, as much as possible, away from all contact with the atmosphere, constitute a much more efficacious manure than those resulting from a fierce, quick fire.

In order to render ashes which have not been lixiviated more active, they are sometimes mixed with recently calcined or pulverized lime; and these substances, after having been carefully mixed together, are slightly moistened. By means of this process, the potash contained in the ashes is rendered caustic. A small quantity of this mixture is used as a dressing for clover; in paring and burning, also, a little lime is generally mingled with the ashes of the turf.

Although this may appear to be the proper place for entering into a consideration of the operation of paring and burning, we shall, nevertheless, defer all mention of it until we come to treat of tillage generally, to which division it certainly belongs.

Of all the lixiviated ashes that are used, the refuse ashes of bleachers and soap-boilers are generally preferred. These contain only a small quantity of potash, but are mixed with lime, and not unfrequently with gelatinous portions of the residue of the melted fat and other substances used in the manufacture of candles and soap. It not unfrequently happens that soap manufacturers mix the sweepings of their houses and yards with the ashes; but this does not tend to improve them. The excellent effects resulting from this species of manure are now so well known, that it is eagerly bought and carried to immense distances; but not more than twenty years have elapsed since it was thrown away as rubbish.

This kind of manure is usually devoted to meadow-land. The ashes are spread over the turf; whence, in a very short time, they cause grass or the varieties of clover to appear, and replace the moss or stunted grass which previously grew there.

Nor are these ashes productive of less beneficial effects on arable land, only, like all other manures of a similar nature, care must be taken that they shall be intimately and completely blended with the soil; and to effect this, they must be only superficially buried at first, in order that the harrow may reach and distribute them. The quantity usually allowed for an acre of land is eighteen, twenty, or, at most, thirty bushels spread equally over it. There are places in which agriculturists do not scruple to pay from five to six rix-dollars (21s. 8d. to 25s. 6d.) for an amelioration of this nature; but in other districts it can be procured at a much cheaper rate.

It is not, however, productive of its most beneficial effects, unless the land to which it is applied be thoroughly impregnated with stable manure: on an impoverished soil, it seldom answers the expectations of those who make use of it. This accounts for the fact that the practice of using this substance is held in the highest estimation in those places where land is kept in pretty tolerable condition. Its effects, too, are then far more durable. Many persons assert that they are perceptible for ten or twelve years; but such is not the case, as Benekendorf justly observes, unless the land is manured afresh.

In places where there is a superabundance of wood, and where the demand for this substance is so small that the most profitable use which can be made of it is to subject it to incineration, in order to obtain potash from it, the residue resulting from this operation may be used with the greatest advantage for the amelioration of land, and the benefits thus obtained are often so great as to cover the whole of the expenses. These ashes are carried to soils which have been repeatedly ploughed, or are used to accelerate the amelioration of newly-tilled forest land. Every farm possesses some portion of lixiviated ashes; and however small this portion may be, it is still worth while to preserve it. If, as is generally the case, the ashes are thrown together in a heap on the dung-hill, they are productive of little or no good, because they do not produce all the benefit of which they are susceptible, unless spread thinly and evenly over the soil. Here, on the contrary, they would be amassed together, and likely to destroy the vegetation on those spots with which they came in contact.

Not only do peat ashes differ essentially from wood ashes in containing little or no potash, but the constituent parts of ashes resulting from varieties of peat are likewise very dissimilar. Lime generally forms the chief constituent of these ashes, provided that the peat from which they are obtained does not contain too large a portion of sand. This lime exists in the form of a carbonate, or in conjunction with sulphuric, phosphoric, and acetic acids. It is usually combined with a considerable portion of oxide of iron, and sometimes, also, of sulphate of iron, when this latter substance has not been decomposed by the intensity of the fire.

The differences which are observable in the properties of peat ashes regarded as a manure, probably arise from the variations which exist in the nature of the constituent parts of peat itself. There are as yet so few well authenticated experiments on the nature of peat ashes, or carefully investigated analysis of them made with reference to their ameliorating qualities, that nothing positive can be said on the subject. It has everywhere been found that light friable ashes are productive of more beneficial effects than those which are heavy, doubtless because they contain less silica. Some persons prefer the white ashes, others the grey, and others those which are of a reddish hue: this latter colour arises from the presence of oxide of iron. I have seen more harm than good resulting from the use of peat ashes of a red brown hue, which contained a great deal of iron, and also of silica, and am, therefore, inclined to believe—at any rate, until further experience shall convince me to the contrary—that oxide of iron is not productive of beneficial effects on vegetation. This point, certainly, is well worthy of investigation, especially in those countries where a great deal of peat is burned. This species of ashes is the more frequently used as manure, in consequence of there being no possibility of applying it to any other purpose.

But in some parts of England and of Holland, peat is burned expressly for the purpose of making use of its ashes in the amelioration of land. Considerable extents of marshy land are devoted to the growth of peat. Kilns or furnaces, constructed of stone or clay, are built near to these places, at the bottom of which, on the grating, a layer of dry peat is laid first, which is succeeded by a layer of peat in the state of moisture in which it is taken from the marsh. The undermost layer is then set on fire, and its heat speedily dries the one above it, and causes it also to ignite; so that after the fire is once permanently kindled, it can be kept up without the necessity of adding more dry peat. The combustion is never suffered to proceed too rapidly, because it is well known that the ashes lose much of their ameliorating properties when the peat has been too rapidly consumed. The ashes are withdrawn from beneath the grating, and thus the process goes on, and with it the formation of fresh ashes; while those that have been produced are carried away.

Latterly, so great a virtue has been attributed in England to the action of ashes, that agriculturists have been advised not only to burn the stubble which is left on the ground after the corn has been reaped, but also to strew the whole of the straw over the soil and destroy it by combustion. In support of this advice, experiments have been brought forward to prove that much greater benefits have been thus derived from the straw, than it would have produced if mingled with the dung. We shall not enter into any discussion with respect to the merits or demerits of this theory; because it can only be applicable to certain peculiar circumstances and to very fertile soils. The practice of setting fire to the stubble, which for this purpose is left very long, is much followed in Hungary, in districts where the soil is very rich.

The residue of salt-works, and the sediment which settles in or attaches itself to the sides of coppers or boilers, which matters are often mixed with ashes, may be classed among the number of very active manures. Agriculturists eagerly purchase these substances, and not unfrequently at a very high price. The sediment of large coppers or boilers is, for the most part, composed of gypsum; sometimes, however, it contains a little salt. Many persons prefer it to gypsum; while others do not attribute an equal value to it.

Agriculturists have been frequently led away and deceived by wonderful accounts of various salts, which, if employed in ever so small a quantity, were to produce miraculous effects. These offsprings, however, of quackery and an excessive love of gain are, happily for us, rapidly losing ground.*

But I must not be understood to confound those artificial compositions of gypsum, oxide of iron, common salt, &c., and, amongst others, the valuable essays and recommendations of Lampadius Freyberg ("Leipsicher Economishe Anzeigen Michaelis," 1805. A.) with those ridiculous inventions; for these are used in suitable proportions, and, not like the miraculous salts, in quantities not exceeding a few ounces or pounds per acre.

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* Not so in this country. "New manures" were never so numerous as at the present time.

There does not appear to be the least doubt that by using successively and appropriately warm, active, animal manures, durable and refreshing vegetable matters and ameliorations composed of mineral substances, which accelerate decomposition, that by successively bringing into action one or other of the different varieties of each of these species of manures, a greater amount of produce may be obtained than if one kind only were used. But in order to obtain this success, attention, doubtless, must be paid to the order, proportion, and period which best agrees with the nature of the soil, the condition in which it is, and the number of crops it has borne since last ameliorated. In many countries, certain positive rules have been laid down with regard to this subject; but these rules want practical and fundamental utility. Theoretically speaking, nothing more can be said on this subject than we have already advanced, because we look in vain for positive and well authenticated experiments calculated to remove our doubts. There is a wide field open to the researches of the chemist and scientific agriculturist; and it is to be hoped that the direction of a patient, scientific, and accurate investigation to this subject, will not fail to produce new and important discoveries, which will teach us how to apply all those substances with which we are furnished by nature, so as best to attain the end for which they were bestowed, namely, the multiplication of living beings, and of the comforts and necessaries of life.

Since Nau Reissert and Seitz have opened the lists in the "Annals of Agriculture" ("Annalen des Ackerbau," vol. ix. p. 210), we may venture to hope that new experiments will soon determine how far certain species of manures are suitable to certain plants, both as regards their influence on the abundance and quality of the produce. All that is at present known on this subject will be narrated when we come to speak of the cultivation of each separate kind of produce.

An agriculturist who has at his disposal those kinds of manure which are not in general use, and who knows how to employ them properly, may venture to deviate from that straight path which a person who cannot procure these substances, or does not know how to use them, must tread without swerving. By means of this variety of manures, the former may adopt a system of cultivation, a rotation, or succession of crops better adapted to the circumstances and the demands of the passing hour, or to his own convenience, than that which he would otherwise be compelled to follow. When he can obtain street mud, or sweepings, the residue of some manufacture, or a supply of rich mould, he will be able to save the stable manure, and perhaps diminish the extent of land devoted to the purpose of raising fodder. Gypsum preserves to naturally rich lands the capability of producing clover for a considerable period, provided that the soil is not too deeply ploughed.

But, on the other hand, those agriculturists who do not possess such extraneous means, must not allow themselves to be tempted to imitate their more fortunate neighbours, or strive to emulate the brilliant success, with the causes of which they are too frequently unacquainted.

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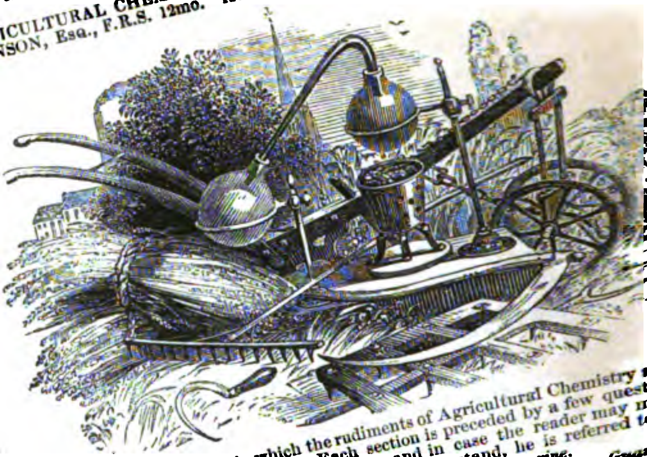

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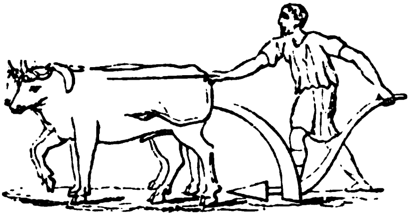

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# Life Department.

The advantages of Life Insurance are as yet but little understood, and in but very few instances embraced by the agricultural population of this kingdom; yet it must be manifest that in a country where such a great proportion of the soil is subject to the laws of entail, copyhold tenure, and leases of different descriptions, the value of which mainly depends upon the duration of human life, that the landed interest possesses, through the members of its own class, ample means of maintaining an Institution for Life Insurance, the effects of which must be to encourage industry and economy, to lighten the pressure of payments which depend upon the lives of individuals, and to alleviate the melancholy consequences in which the widow and the orphan frequently become involved by the decease of the head of the family.

The owner of the soil, from the charges he is frequently compelled to make upon his estate, is deeply interested in Life Insurance, without reference to his connection with the tenant; but here also he is interested, inasmuch as if the tenant has secured himself by a Life Insurance, the landlord may be spared the painful feelings of paying himself arrears of rent, too frequently due at the decease of the tenant, out of the stock of the farm, and to which alone the widow and family can look for the means of future existence, or perhaps temporary support. To the tenant Life Insurance is of paramount importance, inasmuch as by laying aside a small amount annually he may secure a sum at his death for the benefit of his family, which may afford them a provision commensurate with the sphere in which they have been accustomed to move.

Nor in these advantages is the labouring class forgotten, as a plan has been arranged whereby that portion of the population will be enabled, in proportion to their means, to invest their small savings in such a manner as may secure, if not a full support, at least a moderate maintenance in sickness and old age. Although the savings of the labourer must of necessity be limited, yet it is well known to those who have paid attention to the subject, that the sums now annually contributed to benefit societies by that class, including very many expenses attendant upon them, might be applied in a manner which would in the end be much more beneficial.

Thus as the interests of the landlord, tenant, and labourers, are interwoven in their respective positions in life, so are they linked together closely in the beneficial effects which must result from availing themselves of the advantages of Life Insurance. To the two former classes, therefore, on their own account, as well as to set an example to, and to promote the comfort of the latter, this Institution, from the intrinsic merits of the principles of Life Insurance, and from its peculiar constitution, looks with confidence for that support which will render it worthy of that powerful class, the landed interest of Great Britain.

Nor is it only to the agricultural class that this Institution offers its advantages; it holds out a resource against the loss of income in all its shapes and bearings: it provides a fund for old age, for the clerk whose income fails with his office; for the creditor whose whole security is the life of his debtor; for the husband whose only income is his wife's dower; for the dependant upon an annuity for another's life; for the tenant bound to repairs, or to pay fines for renewals; for those parents or guardians who have paid apprentice fees, and such apprentice dies, and it then becomes an object to regain the money so expended; for those who would provide a fund for the education or marriage of their children, or who would secure an independence to the younger branches of their family; and in general for the many contingencies, against which a moderate or uncertain income affords no adequate provision.

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Short Terms may also be assured, at greatly reduced premiums, to meet reversionary interests or contingent remainders.

In order to suit the convenience of those who anticipate an increase of income, arising either from promotion in office, increase of business, accession of property, or any other cause, a scale of premiums has been arranged to take a lower rate at first, gradually ascending until it becomes fixed for the remainder of life.

So, on the contrary, where persons prefer paying a higher rate early in life, and so go on decreasing until the premiums become very small, a scale of premiums has been provided to meet these views.

When the Insurance is for the Whole Life, ONE-HALF OF THE PREMIUMS only may be paid for the first five years after the date of the policy; the other half to remain subject to the payment of interest annually, to be deducted from the amount assured, or to be previously paid off at convenience.

By a late Act of Parliament, 5th and 6th William IV., cap. 64, Policies for any sum, not exceeding £50., may now be issued at a stamp duty of 2s. 6d., and from that sum to £100 at a duty of 5s., instead of the former duty of 20s., which will be found of great advantage to those who wish to insure only small sums at one time.

Life Policies will, at any time after four years, be purchased at their equitable value; or should circumstances render it inconvenient to continue payment of the premiums, another Insurance for a less sum, without any further premium, may be obtained.

## The Advantages of Life Insurance.

A popular writer has, on this head, the following observations:—"It may be felt by many, that, admitting the duty in full, their income is nevertheless insufficient to enable them to spare even the small sum necessary as an annual premium for Life Insurance. The necessities of the present are, in their case, so great that they do not see how they can afford it. We believe there is no obstacle which is apt to appear more real than this, where an income is at all limited; and yet it is easy to show that no obstacle could be more ideal. It will readily be acknowledged by everybody who has an income at all, that there must be some who have smaller incomes. Say, for instance, that any man has £400 per annum; he cannot doubt that there are some who have only £350. Now, if these persons live on £350, why may he not do so too, sparing the odd £50 as a deposit for Life Assurance? In like manner, he who has £200 may live as men do who have only £175, and devote the remaining £25 to have a sum assured upon his life; and he who has £100 a-year may live as those who have £85, applying the other £15 for a Life Assurance. The latter sum would secure nearly £750 to the family or survivors of a man twenty-seven years of age when he effected the assurance, and nearly £600 to the survivors of a man thirty-six years of age. £15 would secure to a person 23 years of age, an annuity of £50 on attaining 50, to a person aged 31 on attaining 55, to a person 38 years of age on attaining 60, and to a person aged 46 on attaining 65. It would secure an annuity of £60 to the widow of a man aged 30 on his demise, his wife being the same age; nearly £500 for a child just born on attaining 21, and nearly £300 to a child 6 years of age on attaining 21. It may require an effort to accomplish this; but is not the object worthy of an effort? And can any man be held as honest, or any way good, who will not make such an effort, rather than be always liable to the risk of leaving in beggary the beings whom he most cherishes on earth, and for whose support he alone is responsible?"

ANNUAL PREMIUMS TO ASSURE £100 ON A SINGLE LIFE.

| Age. | Premium. | | | Age. | Premium. | | | Age. | Premium. | | | Age. | Premium. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | £. | s. | d. | | £. | s. | d. | | £. | s. | d. | | £. | s. | d. |
| 15 | 1 | 12 | 4 | 27 | 2 | 3 | 5 | 39 | 3 | 1 | 5 | 50 | 4 | 10 | 3 |
| 16 | 1 | 13 | 1 | 28 | 2 | 4 | 8 | 40 | 3 | 3 | 5 | | | | |
| 17 | 1 | 13 | 9 | 29 | 2 | 5 | 11 | | | | | 51 | 4 | 14 | 5 |
| 18 | 1 | 14 | 6 | 30 | 2 | 7 | 1 | 41 | 3 | 5 | 5 | 52 | 4 | 18 | 10 |
| 19 | 1 | 15 | 3 | | | | | 42 | 3 | 7 | 6 | 53 | 5 | 3 | 5 |
| 20 | 1 | 16 | 1 | 31 | 2 | 8 | 4 | 43 | 3 | 9 | 8 | 54 | 5 | 8 | 5 |
| | | | | 32 | 2 | 9 | 8 | 44 | 3 | 12 | 0 | 55 | 5 | 13 | 9 |
| 21 | 1 | 17 | 0 | 33 | 2 | 11 | 1 | 45 | 3 | 14 | 5 | 56 | 5 | 19 | 6 |
| 22 | 1 | 17 | 11 | 34 | 2 | 12 | 7 | 46 | 3 | 17 | 1 | 57 | 6 | 5 | 8 |
| 23 | 1 | 18 | 9 | 35 | 2 | 14 | 3 | 47 | 3 | 19 | 11 | 58 | 6 | 12 | 1 |
| 24 | 1 | 19 | 11 | 36 | 2 | 15 | 10 | 48 | 4 | 3 | 0 | 59 | 6 | 18 | 9 |
| 25 | 2 | 1 | 0 | 37 | 2 | 17 | 7 | 49 | 4 | 6 | 6 | 60 | 7 | 5 | 5 |
| 26 | 2 | 2 | 2 | 38 | 2 | 19 | 5 | | | | | | | | |

## Hail Department.

In soliciting the attention of Farmers and others who may be interested in protecting themselves from losses by Hail-Storms, the Directors of this Office trust it will be borne in mind that the "Farmers' Fire and Life Insurance Office" was the first in this country to introduce a plan of protection against a calamity, which the events have proved to be no less disastrous in its effects than fire; they therefore think that they have a claim upon the grateful feelings of the British farmers, and they feel that they may rely with confidence upon a response.

The Rates of premium to be charged are, for Wheat, Barley, Peas, and Rye, *sixpence* per acre, and for Oats, Beans, Tares, Turnips, and Potatoes, *fourpence* per acre. The premium on Glass insurance is 20s. *per cent.* No insurance is effected on glass for a less amount than £50. *No average clause*, so that the sufferer will be certain of receiving the full amount of his loss, to be settled as in the case of loss by fire; and should any dispute arise, to be referred to arbitration.

The surplus profits, after paying an annual dividend of £4 per cent. to the shareholders, and providing for a reserve fund, will be divided every *third* year between the Shareholders and the Insured.

Prospectuses may be obtained at the office, or will be forwarded, post-free, upon application. The usual commission to Solicitors.

Agents are appointed in the Principal Towns in the Kingdom.

W. SHAW, Managing Director.

# Farmers' and Graziers'
# MUTUAL CATTLE INSURANCE
# ASSOCIATION.

*OFFICES—366, STRAND, LONDON.*

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WM. YOUATT,* Director of the Royal, Farmers' and General, Fire and Life Insurance Institution, and Governor of the Royal Agricultural Society.

(With power to add to their number.)

[The gentlemen whose names are marked thus † are Directors of the Association.]

WILLIAM FENTON, Esq., MANAGER.

WILLIAM YOUATT, Esq., CHIEF CONSULTING VETERINARY SURGEON.

Messrs. OLIVER and LINDSELL, Raymond Buildings, Gray's Inn, SOLICITORS.

**Bankers: The London and Westminster Bank, Throgmorton-street.**

1. The especial object of this Association is to give to Farmers, Graziers, and Owners of Cattle, the best means of protecting themselves against losses

by those *diseases and accidents* which they can neither foresee nor control, but which have hitherto been most injurious, and often ruinous to thousands.

2. In effecting this, two great principles must be kept in view, viz., *Economy* and the *Prevention of Fraud.* To secure *economy* the Association is *mutual.* Nobody can be benefited by charging too high, save the subscribers themselves; none injured by paying too little but the subscribers themselves, should they become claimants.

3. To *prevent fraud,* no owner will receive in any case more than two-thirds of the bonâ fide value of the animal lost, but he will be entitled to one-third of the value of the skin and carcass.

4. Subject to these leading principles, and some other regulations, the whole of which cannot be set out in this prospectus, the Association will ensure the NEAT CATTLE and COWS (excepting Cows kept in towns) of all they consent to admit as Associates, against death, whether occasioned by sickness, *unforeseen accidents,* calving, contagion, *pleuro-pneumonia,* or by the slaughter of the animals in consequence of being tainted with any disease.

5. The Association, however, will not pay for animals which may die of blows, wounds, fractures, bad treatment directly caused by the owner, or be his instigation, or direction, or neglect, or owing to any disease with which they might be affected before they were assured. They must be in a healthy state when offered, and not neglected afterwards; otherwise the contract will be void.

6. An owner may insure his stock, and sell, exchange, substitute, or increase, up to the value he insures; but he must never increase the value of his stock beyond the value for which he has paid, without effecting a further insurance, and paying in proportion, otherwise he will forfeit his contract. In cases of "substitution," the insured must make a *monthly* return of new animals admitted; but in "additions" a new insurance must be effected immediately.

Graziers in the habit of constantly changing their Stock, when insured, will be permitted to do so, upon payment of a small additional per centage.

7. Insurances may be effected in two ways:

1st. The Owner may have his stock valued by the Inspector of the Association, and pay upon the full amount, and receive two-thirds of the market value of the animal dying (*i. e.,* the value of it the day before the disease manifested itself), and allowed, in addition, one-third of the value of the skin and carcass. For example:

If the full value of the stock, allowing for the improving condition of the animals during the coming year of insurance (for their increasing value during that period *must be* calculated), amounts, or will amount, to £1,000, then the premium on £1,000 being paid, if any one or more die, two-thirds of their market value will be paid, be they worth what they may.

2nd. If the owner elects making his own estimate and average, he will receive two-thirds of the said value of the animal dying, *provided* such value be not more than the average he has specified; and when of smaller value, two-thirds of such smaller value only, the Directors having power to grant additional compensation, should they see fit. For instance:

If the stock consists of 100 head, and the average fixed be £10, then the premium to be paid will be upon £1,000; and if one or more die, of the value of £10 (to be certified by the Inspector), the Owner will be paid two-thirds of his average (and, in addition, allowed one-third of the value of the skin, &c.); if worth only £8, then two-thirds of £8, &c.; but if th eanimal were worth £20, he will receive only two-thirds of his average (£10).

8. No Animal under the age of 12 months will be insured.

9. The Association will not interfere with the treatment of the usual Veterinarian or Farrier of the Owner. Should they, however, deem it requisite to do so, they will pay the expense out of their own funds. But in all cases of serious sickness, the Association will require immediate notice to be given to the Agent and Inspector.

10. If the Veterinarian recommend that the sick animal ought to be kept separate from the rest, it must be so separated, or the contract with the Association will be void as regards any loss arising from contagion.

11. In extreme and urgent cases the Owner will be allowed the power to slaughter sick animals, *provided* it appear that he would have sustained injury by not doing so before the Inspector could arrive; the propriety of so acting to be certified by the Inspector.

12. All animals will be protected, and the Owner be entitled to claim payment for the loss *of every animal dying* 21 *days after the day on which the proposal is made, and a receipt given by the Agent for the Premium.*

13. A reserve fund of 5 per cent. per annum, to form a guarantee fund for the Association to the extent of £50,000, to meet extraordinary losses, will be made.

14. Should the rates charged be more than sufficient to meet the losses, expenses, and contribution to the guarantee fund, the Association may place to the credit of every one assuring, his proportion of the surplus in reduction of his premium of insurances for next year.

15. A consulting Veterinary Surgeon, being a Graduate of the Colleges of London or Edinburgh, or more than one, if required, will be appointed to each Agent's district.

16. The insurance will only extend to Cattle upon the farm or lands specified in the Declaration.

17. In the event of any person being insured in any other Society, notice must be given, in order that an indorsement may be made upon the Declaration to that effect.

18. Losses from lightning or fire will not be made good, such being paid for by the Fire Offices.

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This Association has been formed on the *Mutual* principle, as being the most economical, and the best and most legitimate mode of individual protection. Experience has demonstrated the security of well-established and prudently-managed Mutual Insurance Societies. In such a society there are no conflicting interests between the Insurers and the Insured; the *profits* are not consumed in the payment of interest upon a subscribed capital, but the contributions of the Members *belong exclusively to themselves*, and whatever surplus remains beyond the amount of losses and expense of management is returned either in the shape of a *bonus*, or is applied in reduction of future Premiums.

Had the "Farmers' and Graziers' Cattle Insurance Association" been formed as a proprietary Company, with a large subscribed capital, it might possibly have paid a handsome per-centage to the Shareholders, but the Rates must have been higher, and the general advantages to the Insured would have been diminished.

The leading feature of the proprietary system is, that the subscribed capital affords a guarantee or security for the payment of claims which the mutual system lacks, and that the Assured is thus compensated in safety for what he wants in money. But the hollowness of this reasoning is evident, when it is considered that a combination of Assurers, each paying fully what experience declares is necessary to make good their mutual arrangements, is a transaction free from all risk—in the ordinary sense of the word—and can only fail in the event of a change in the laws of nature, or such an alteration in the condition of the country as no kind of security could withstand.

In the case of this Association, the risks have been carefully calculated from the best experience which could be obtained as to the rate of mortality amongst cattle, and the results hitherto confirm the conviction that the Premiums are sufficient to meet all ordinary contingencies, as well as gradually to form a guarantee-fund; and the success which it has already had, and which, it is presumed, has placed it on a sure and permanent basis, renders a paid-up capital altogether unnecessary.

Thus, then, the Assured has not only the benefit of protecting himself against destructive losses among his cattle, at the lowest rate of Premium consistent with the risk, but retains in his pocket what would otherwise have gone to the payment of interest on capital, had this been a proprietary Company.

There are, at the present time, many Societies for the Insurance of human life on the Mutual principle, and although they depend entirely and exclusively on the contributions of their members, there is no instance on record where a claim has fallen in which those contributions could not meet.

The system of Mutual Assurance, conducted on a large scale and upon a proper footing, involves no risk; while, at the same time, seeing that any surplus beyond the amount of losses and expense of management is secured by the Insured in future diminished premiums, the charges must be considered as reduced to the lowest rate which the necessities of the case require, and are at the same time sufficient to meet every contingency.

N.B. References can be given to several persons in Dorsetshire, Cheshire, Lancashire, Nottinghamshire, Yorkshire, &c., who have experienced losses, and have been promptly paid. In these cases some have lost six and some nine animals.

## PREMIUMS.

Neat Cattle and Cows, against death by all diseases and accidents, save *pleuro pneumonia* (usually called the "Epidemic"), 30s. per £100 value.

Including *pleuro pneumonia*, 20s. per cent. additional; being at the rate of 50s. per £100 value.

*Pleuro pneumonia* will *not* be taken alone at this latter rate.

Animals under two years old will not be insured against the disease called Quarter-ill or Black-leg.

The rates of Premium to be charged for Agricultural horses are under consideration.

Prospectuses and every information may be obtained by letter (post paid) addressed to Wm. Shaw, Esq., 366, Strand, London; or from the Agents in the Country.

HENRY FLOWER, Secretary.

# PORTRAITS

OF THE FOLLOWING

## EMINENT BRITISH FARMERS

WILL APPEAR IN SUCCESSION IN THE

# FARMER'S MAGAZINE,

PUBLISHED MONTHLY.

Earl Talbot
Lord Western
Sir C. Morgan, Bart.
H. Handley
T. Bates
J. Ellman
J. Smith, Deanston
S. Grantham
J. Price
J. Tull
Jonas Webb
C. Hillyard
H. Chamberlain
Colonel Le Couteur
&c., &c., &c.

PORTRAITS OF EARL LEICESTER, EARL SPENCER, J. BAKEWELL, C. COLLINS, P. PUSEY, M.P., DUKE OF RICHMOND, have already appeared.

This Magazine has been established eleven years, and contains ONE HUNDRED AND NINETY-TWO COLUMNS of closely-printed letter-press; and is beautifully embellished with highly-finished

## **Steel Engravings of Prize Animals,**

AND

## NEW AND IMPROVED AGRICULTURAL IMPLEMENTS.

Engravings of Animals and Implements, to which Prizes were awarded at the late meetings of the Royal Agricultural Society of England at Oxford, Cambridge, Liverpool, Bristol, Derby, and Southampton, and at the shows of the Highland and Agricultural Society of Scotland, have appeared in succession in the numbers of this Magazine; and it is the intention of the Proprietors to adopt the same course with respect to the Animals exhibited at the Royal Agricultural show at Southampton, and at the forthcoming meetings of the Yorkshire Agricultural Society and the Highland Society.

Farmers, Graziers, and Breeders of Cattle thus obtain the two-fold advantage of acquiring the readiest information in reference to the selection of Animals, either for purchase or hire, most likely to improve their stock, and are made early acquainted with all the practical improvements in Husbandry and farm management.

Immediate notice is taken of all new publications bearing directly upon or connected with Agricultural management in all its branches, and copious extracts of the most valuable parts given.

Improvements in Agriculture abroad are noticed from time to time, and extracts from foreign writers upon Agricultural subjects are translated and given, when found to be of practical interest.

The Agricultural articles are supplied by the most eminent practical Agriculturists of the United Kingdom; and all matters calculated to benefit the practical Farmer which occur throughout the month are carefully compiled and inserted. The most accurate reports are given of the proceedings of the various Agricultural Societies and Farmers' Clubs in the United Kingdom.

New statutes, affecting the interests of both Landlord and Tenant, appear as soon as possible after they receive the Royal Assent; with Remarks, Explanations, Notes, and Indexes.

Ample Monthly Reports of the state of the Crops; Review of the Corn Trade; Hop, Wool, and Meat Markets; Notices of Cattle Fairs, and all incidental facts in the remotest degree connected with the interest or advancement of Agriculture.

## OPINIONS OF THE PUBLIC PRESS.

We regret that the state of our columns will but allow us to avail ourselves of a small portion of the invaluable mass of information contained in this magazine. We should hope there are very few of our agricultural friends who do not patronize this periodical, and richly does it merit their support.—*Cambridge Advertiser.*

The work should be in the hands of every farmer in the kingdom; but if this be not accomplishable, four or five neighbouring farmers might have it, as common or joint-stock property among themselves; and making the subject in the several numbers matters of discussion, could not fail to render them more conversant in the various improvements now spreading in agriculture. Let the numbers be lodged, when well conned over by the members of the little fraternity, at one of their domiciles. We conclude by saying that the Farmers' Magazine is a library in itself, for the end desired; and, whether from the extracts of the most approved authorities, or from original matter, it is among the best publications of its kind in our day.—*Chester Courant.*

The present number abounds with matter of a practical and highly interesting nature, and fully sustains that reputation for which it has long been conspicuous.—*Bolton Chronicle.*

This is indeed a periodical of genuine merit, and one which cannot well be dispensed with by those cultivators of the soil, whose enterprising spirits urge them to keep pace with modern improvements in agricultural science. The breeder of stock, however experienced, will also enrich his fund of information by a perusal of the interesting and useful pages of this intelligent publication, which in fact furnishes a concentration of all the experiments and useful discoveries in the science of which it so ably treats.—*Cumberland Packet.*

Besides the engravings, which alone are worth the whole of the money charged for the number, there are eighty pages of valuable information.—*Nottingham Review.*

This ably edited Magazine contains in every number a vast fund of information, exceedingly interesting and useful to the agriculturist. It is besides the cheapest periodical of its class. We heartily recommend this publication to our agricultural friends.—*Kent Herald.*

Is embellished with two engravings beautifully finished. The contents of the number are varied, but are, for the most part, devoted to agricultural matters, pointing out the improvements in the cultivation of the soil, manuring, feeding, and fattening cattle, &c., &c. This is one of the best and cheapest works of the kind that is published. It is, in fact, within the reach of all agriculturists.—*Western Times.*

This is a work which we can safely recommend both to the theoretic and practical agriculturist. It is replete with valuable information. The part for this month is embellished with two engravings.—*Blackburn Standard.*

The number for the present month contains two beautiful engravings. But these, altogether valuable in themselves, are nothing as compared with the work itself, which abounds with information highly interesting to all, and of great benefit to those engaged in agricultural pursuits.—*Bolton Chronicle.*

THE FARMER'S MAGAZINE, Vol. XIX., price 10s. 6d., is now published, in royal 8vo, cloth boards, uniform with Vols. I. to XVIII., and may be had, by order, of all Booksellers.

OFFICE—24, NORFOLK STREET, STRAND, LONDON.

THE

# MARK LANE EXPRESS

IS THE LARGEST

**Agricultural and Commercial Newspaper,**

AND IS

**PUBLISHED EVERY MONDAY EVENING**

IN TIME FOR POST.

The object of the Proprietors of THE MARK LANE EXPRESS has been, and is, to render it in every way an efficient organ of the Agricultural Class, as a medium for giving circulation to the Proceedings of the Royal Agricultural Society of England, the Highland and Agricultural Society of Scotland, the Royal Agricultural Improvement Society of Ireland, the Agricultural Protection Society for the United Kingdom of Great Britain and Ireland, and of every Agricultural Society and Farmers' Club in the Kingdom. All political and party discussions are carefully avoided, except such as are purely Agricultural; and to be the medium for imparting useful *practical* information, is the great object of the Conductors: since its establishment, now more than twelve years, this course has been steadily adhered to, and the result has been, the accession of a numerous list of Subscribers, comprising many of the most influential Agriculturists in the Kingdom.

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THE MARK LANE EXPRESS STANDS UNRIVALLED.

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THE LATEST REPORTS OF THE
CATTLE, PROVISION, WOOL, SEED, HOP, MALT, AND COMMERCIAL MARKETS,
APPEAR, WITH THE

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- Imports of Foreign Grain and Seeds
- Seed Market
- Monthly Reviews of the Corn Trade
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- Reports of Mark Lane on Monday to the *Close of the Market*
- Imperial Averages
- Comparative Prices of Grain, and of Meat in Smithfield, with the Corresponding Period in the Previous Year
- List of Vessels Laden with Grain, Seeds, Cake, &c., and Bound for Great Britain, which have Passed the Sound
- Report from the Gazette of Foreign Grain Imported into the Principal Ports
- Country Cattle Markets
- Fairs
- Wool Markets
- Reports of Sales of Foreign and Colonial Wool
- State of the Woollen Trade and Manufactures
- Quantity of Wool Imported Weekly
- Prices of Cotton, Spirits, Hops, Tallow, Oils, and Metals
- Mining Intelligence
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- Horticulture
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